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I N D E X

Colstrip 3 & 4

THURSDAY, JANUARY 29, 1976

The hearing reconvened at 8:35 A.M. on Thursday, January 29, 1976, in the Chambers of the Montana House of Representatives, State Capitol, Helena, Montana.

The Honorable Carl M. Davis, Hearings Examiner, presided over the proceedings.

APPEARANCES:

Applicants:

William M. Bellingham, Esq.
John L. Peterson, Esq.
John Ross, Esq.

Department of Natural Resources and Conservation:

William G. Sheridan, Esq.
Donald MacIntyre, Esq.

Northern Cheyenne Tribe, Inc.:

Peter Michael Meloy, Esq.

The following proceedings were had:

HEARINGS EXAMINER: Proceed.

MR. PETERSON: All right, the applicants will call their next witness, Dr. Peter R. Edmonds. For the record, Mr. Davis, I would like to at this time enter into the record corrections to the statement filed by Dr. Edmonds on pages 28 and 34 of his prepared statement. I have heretofore served a copy of these corrections on opposing counsel and the Hearing Examiner and reporter, and I will have these pages retyped for the purpose of inserting the corrected pages in the transcript.

HEARINGS EXAMINER: Very well.

DR. PETER R. EDMONDS, called as a witness by the Applicants, having been first duly sworn upon his oath, both as to his written direct testimony and as to the oral testimony to follow, was examined and testified as follows:

MR. PETERSON: May the record also show that there is in attendance here today two witnesses for the Department of Natural Resources, Dr. C. C. Gordon and Phillip Tourangeau.

HEARINGS EXAMINER: Will you stand up, gentlemen, and we will acknowledge your presence. Very well, you may proceed with your cross-examination.

(THE WRITTEN DIRECT TESTIMONY OF DR. PETER EDMONDS WAS DIRECTED TO BE INSERTED AT THIS POINT.)

TESTIMONY OF PETER R. EDMONDS

My name is Peter R. Edmonds. My business address is Westinghouse Electric Corporation, Environmental Systems Department, Box 1899, Pittsburgh, Pennsylvania, 15230. I am Manager of Terrestrial Systems for the Westinghouse Environmental Systems Department (WESD), located at the Research and Development Center, in Churchill, Pennsylvania. It is my responsibility to supervise, design, conduct and evaluate environmental programs concerned with the assessment of terrestrial effects and impact projection associated with electric power generation and transmission and mining. Since 1972 when I accepted a position with the Environmental Systems Department as a Senior Scientist and after my 1974 appointment as manager, I have been responsible for the interdisciplinary assessment of impacts associated with major projects in Montana, Wyoming, Arizona, Colorado, Oklahoma, South Carolina, Illinois, Pennsylvania, New Jersey, Tennessee and Wisconsin. During this period,as part of the WESD internal strategic research programs, I have conducted research on the terrestrial impacts associated with electrical power generation. The majority of my research has been directed toward an assessment of cooling tower effects on the terrestrial environment and the impact associated with electrical power plant stack effluents on biota.

I received my Bachelor of Arts degree in Chemistry and Biology from Wilmington College in Wilmington, Ohio in 1963. My Master of Arts degree in Botany was obtained from Miami University in Oxford, Ohio in 1965. My Ph.D. degree in Botany and

Bioecology was obtained in 1972 from Rutgers University, New Brunswick, New Jersey.

I have been continuously employed in positions associated with biology since 1956. Early employment as a clinical hematologist was with Columbia Presbyterian Hospital, Columbia College of Physicians and Surgeons and Wilmington College. Other employment at Wilmington College was as a Laboratory Instructor in Biology until my graduation in 1963. At Miami University I was employed for two years as a Teaching Assistant in the Botany Department. Teaching included both lecture and laboratory course work in general biology and taxonomy. In 1965 I accepted a full-time position as Instructor of Botany at Rutgers University. From 1965 to 1972, I lectured in courses conducted at Rutgers College, University College, Newark College and Rutgers University Summer Sessions. Course work included, general biology, ecology, morphology, phycology, taxonomy and advanced systematics.

Since 1972 additional teaching experience was obtained at Colorado State University at the Westinghouse International School of Environmental Management. Lecture and laboratory course work was presented on the subject of evaluating the terrestrial impacts associated with electric power generation.

I have examined the available evidence applicable to the assessment of the potential bioecological effects which may result from the operation of the Colstrip electrical generating facility. A total of 130 pertinent publications as well as numerous supportive references have been examined. Additional information has been obtained through contact with researchers

knowledgeable in the field of biological effects from air pollution and from personal field studies at fossil fired power plants in Montana, Wyoming, Colorado and Illinois. My evaluation has included an assessment of the potential effects associated with acid precipitation, gaseous effluents and particulate deposition from the four porposed Colstrip generating units.

ACID PRECIPITATION

For acid precipitation to be clearly distinguished from the acidic component of normal precipitation, it may be defined as rain or snow having a very strongly acid pH. It has been suggested by some that acid rain (acid precipitation) may be an environmental concern at Colstrip, Montana. I have carefully examined evidence concerning the acid precipitation question in Montana and have found that Montana does not have an acid precipitation problem at the present time nor will such a problem develop from the operation of the Colstrip generating facility.

The situation may more easily be evaluated by considering the following questions:

What is the pH (acidity or alkalinity) of normal precipitation?

Where has acid precipitation clearly been documented and what caused the situation?

How do conditions near Colstrip compare with clear cases of acid precipitation in northern Europe and New England?

What effects have been attributed to acid precipitation in Montana?

Considering the first question, rainfall normally contains dissolved carbon dioxide in the form of carbonic acid and its ionization products giving it a moderately acid reaction in the

range of 5.5 to 5.7. A pH of 7.0 is neutral, greater than 7.0 is alkaline and less than 7.0 is acidic. The U.S. Department of Agriculture Soil Conservation Service has subdivided acid pH values according to the following scale:

Description	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 - 5.0
Strongly acid	5.1 - 5.5
Medium acid	5.6 - 6.0
Slightly acid	6.1 - 6.5
Very slightly acid	6.6 - 6.9

Since no early direct pH measurements of rainfall were made, the pH of rainfall prior to man's influence must be inferred from indirect evidence. Prior to 1940 in New York State, the indicator dye methyl orange was used to indicate whether precipitation was acidic or basic (alkaline). At no time were dye reactions recorded as being acidic. Methyl orange is yellow at pH values above 4.4 and red at values below 3.1; the transitional color between 4.4 and 3.1 is orange. Therefore, the absence of acidic dye reactions simply means that the pH was uniformly greater than 4.4. By inference, precipitation pH prior to 1940 was assumed to be near 5.7. It had formerly been incorrectly assumed that at pH values lower than 5.7 carbonic acid would dissociate to water and gaseous carbon dioxide and that lower pH values resulted from nearly pure strong acid solutions. However, in the early 1970's, carbonic acid concentrations equaling or exceeding strong acid concentrations in rain water of pH 4.45 were found. This evidence indicates that carbonic acid can occur in acid precipitation and can contribute substantially to the strongly acid reaction. Furthermore, it

was found that precipitation falling in western Pennsylvania from December 1973 through May 1974, had a median pH of 4.5 and contained large amounts of weak acid, presumably carbonic acid. As a result of this, it has been questioned whether the solubility of carbon dioxide in precipitation ever has governed the pH of rainfall.

Discussion of acid precipitation requires a definition of what is and is not "acid". In the absence of direct evidence that precipitation in the eastern United States had an average pH of 5.5 to 5.7, the possibility exists that precipitation may have been as acidic as 5.0 or even 4.5 before man's activities may have influenced it. Therefore, as a basis for reasonable comparison, precipitation having a pH lower than 5.0 will be considered "acid".

In answer to the second question, acid precipitation has been well documented in Sweden and in the New England part of the United States. Precipitation pH data collected in Sweden and other parts of western Europe from 1955 to 1965 has shown that the rain of some parts of Europe has become more acid and other parts more alkaline in those ten years. Precipitation in central Europe from northern France to Poland and the Baltic Sea countries has become more acid by 0.5 to 1.0 pH unit; precipitation in southern Europe has become more alkaline; and that in Great Britain has become slightly more acid (less than 0.5 pH unit). During the ten years from 1955 to 1965, precipitation from air masses that reached Sweden from western Russia had a pH of 4.6 and sulfur content of 3.3 mg/l; the most acid and highest level of sulfur. Air that came from the North Sea

over northern England has a pH of 5.2 and sulfur content of 0.9 mg/l and air that moved across England and central Europe had a pH of 4.7 and sulfur content of 2.6 mg/l. Acidification was attributed to the change-over from combustion of high ash fuels to heavy oil having a high sulfur content (to 4 percent). The result of this change-over was to decrease the quantitites of basic ash constituents such as oxides of potassium, calcium and magnesium reaching the atmosphere which partially or entirely neutralized sulfur dioxide or sulfuric acid. The conversion to oil resulted in a decreased ash content and reduced quantities of particulates reaching the atmosphere with a concomitant increased acid content in the atmosphere. A direct correlation between the acidity in air or in precipitation and the industrial release of sulfur, however, cannot be made.

A very strong correlation has been found between the agricultural application of nitrogenous commercial fertilizers and the nitrogen content of precipitation. The agricultural application of nitrogenous commercial fertilizers has resulted in the release of about twenty percent to the atmosphere. Similarly, it is thought that in Sweden and western Europe, the agricultural application of sulfur-containing commercial fertilizers has contributed significant amounts of sulfur to soils, that sulfide contained in the fertilizers was converted to hydrogen sulfide which was released to the atmosphere, that atmospheric hydrogen sulfide may have reached levels 50 times greater than in normal areas, and the atmospheric hydrogen sulfide was oxidized to sulfuric acid. This more significant agricultural contribution is often ignored or overlooked when

the question of industrial processing or power generation are considered as possible primary agents in causing acid precipitation.

It should be clearly noted that both agricultural fertilization practices and fuel combustion contributed acid-forming compounds to the European atmosphere. In Sweden, nearly all sulfur dioxide emitted into the atmosphere resulted from combustion of oil; generation of power and heat in large units exclusively used oil. Acid precipitation occurred in association with and may or may not have been caused by conversion from high ash fuels to fuel oil.

In the northeastern United States including New England and parts of New York State, increased precipitation acidity accompanied a conversion from predominately coal to natural gas combustion. Associated with this increased acidity, the total sulfur content of rain decreased by 70 percent and the total quantities of particulates decreased in the time period from 1950 to the 1970's. This strongly suggests that the decrease in total particulates, not the sulfur concentration, was the primary factor contributing to acidity. A strong correlation between increased acidity of precipitation from 1964-65 to 1973-74 and increased nitrate levels indicates that the increased nitrate concentrations caused the observed increase in precipitation acidity. Although the source of the increased nitrate levels has not been specifically identified, a similar situation as described for northwestern Europe where the increased nitrogen content of precipitation correlated well with the increase in nitrogen-containing commercial fertilizers is

reasonable to assume. Nitrogen-containing fertilizers are being used in greater and greater quantities in the United States, including New England. This increasing use of nitrogen-containing fertilizers strongly suggests nitrogen fertilizers have been a primary causitive agent for the increased nitrate content of New England atmospheric precipitation.

Numerous recent studies relating to acid precipitation and the forest ecosystem have contributed substantially to our knowledge of acid precipitation geographic distribution, trends, causes and effects. Studies conducted in the New York State and New England region have uniformly indicated an acid precipitation condition.

Precipitation near the central part of the United States including the Great Plains, however, has a nearly neutral pH. Average pH of precipitation for all sampling stations in Michigan has been found to be 6.2, and in Iowa, about 6. In the Austin area of central Texas, average pH of precipitation was found to be about 6.5 to 6.6. In both Iowa and Minnesota, concentrations of sulfate were specifically not related to precipitation pH.

Atmospheric dust contains very fine soil and biological particles derived from regional soils and biota. Eastern Montana soils contain large amounts of free magnesium and calcium carbonates which very effectively neutralize carbonic, nitric and sulfuric acids produced by plants growing in those soils. Atmospheric dust has been found to react with atmospheric sulfates (acids) converting them to harmless gypsum. The enormous buffering capacity of eastern Montana soil carbonates

is expected to effectively buffer atmospheric precipitation in this region from potential acid-forming gases such as SO_2. Current information strongly indicates that little SO_2 is actually converted to sulfate in the atmosphere and that power plant SO_2 emissions very likely contribute little to acid precipitation production. Consequently, it is thought that the neutralizing soil dust contribution to an atmosphere which already contains low potential for forming atmospheric acid will result in a condition which negates the possibility of acid precipitation.

In short, recent evidence indicates three important points. First, the recent increase in precipitation acidity in northwestern Europe and New England was correlated with and possibly caused by increased use of nitrogen-containing fertilizers even though sulfate may have been a contributing factor. Second, the Great Plains region presently has nearly neutral precipitation. And third, airborne dust which is common in the western United States reacts with sulfate, nitrate and carbonic ions in the atmosphere changing them to neutral relatively harmless salts. This, coupled with the already existing low potential for atmospheric acid formation, negates the possibility of acid precipitation occurrence in the region around Colstrip.

In considering the third question related to a comparison of environmental conditions near Colstrip with those conditions which are associated with clear cases of acid precipitation in northern Europe and New England it should be noted that environmental conditions differ markedly between those in eastern Montana and those in New England and northern Europe. New

England and northern Europe have humid climates, acid soils and generally forest vegetation. However, eastern Montana has a semiarid climate, alkaline soils and grassland vegetation. New England receives an average annual precipitation of 42 inches per year distributed evenly over the year; on the other hand, Colstrip, Montana, receives an average of only 14 inches per year of which 57 percent falls in the five months from March through July.

The Colstrip Generating Units 3 and 4 will burn low-sulfur coal (1 percent sulfur or less) whereas both New England and European acid precipitation was associated with natural gas and/or fuel oil combustion and with increasing atmospheric nitrate levels, presumably from increasing agricultural use of nitrogen-containing fertilizers. Eastern Montana characteristically has high atmospheric dust levels associated with its semiarid climate while both New England and northern Europe are forested and have low dust levels. Furthermore, dust as in Montana neutralizes acidic substances in the atmosphere as pointed out previously.

Precipitation in Montana is not presently acid. Precipitation at East Helena, Montana near a lead smelter, slag processing plant and paint pigment plant (Industries which emit quantities of sulfur dioxide) is reported to have an average pH of 6.67, a nearly neutral pH.

Personal inspection of the Billings and Helena areas indicated an absence of acid-precipitation damage to ponderosa pine, douglas fir, limber pine or lodgepole pine. It has been implied that acid rain damage was prevalent in all portions of Montana. My personal observations indicate a complete absence of such

damage in the areas examined.

The last question, relating to what effects have been or could be attributed to acid precipitation in Montana, addresses claims which are voiced by a few individuals. I have carefully reviewed the evidence used as a basis for such claims and found the evidence to be completely nonsupportive. It has been claimed, for example, that "acid rain," specifically the hydrogen ion, causes early casting of conifer needles. The available evidence, however, points strongly to damage being caused by fluoride and not by the acidity in the case of hydrofluoric acid. For example, hydrofluoric acid at a pH of 5.5 causes more pine needle tissue damage than sulfuric acid at a pH of 4.0. If the hydrogen ion was specifically responsible for early casting of confier needles, more damage should have been observed at pH 4.0, a clearly more acid solution than one of pH 5.5.

It had been stated that similar problems due to "acid rain" could develop around the Colstrip generating facility as have occurred near Mt. Storm. Possible acid precipitation damage to Christmas tree plantations near Mt. Storm in the Maryland-West Virginia area was carefully examined from 1969-73. Results of these investigations were presented at the 68th Annual Meeting of the Air Pollution Control Association held in Boston in mid-June 1975. Christmas trees had been damaged both north and south of a coal-fired electrical generating plant composed of two 570 megawatt units. Damage symptoms occurred on several pine species and consisted of apparently random occurrences of needles of various lengths on a single plant. In addition to

short needles, the disease syndrome included curved needles, reduced development of lateral branches and, in some cases, failure of bud development. Intensive research into this phenomenon occurring in the Mt. Storm area strongly indicates that the observed damage was due to a biological causal agent (thought to be mites) rather than any association with acid precipitation.

Experiments in eastern Pennsylvania have duplicated the disease syndrome by placing young pine seedlings and an infected (damaged) branch into a growth chamber which received charcoal-filtered air; however, the syndrome did not develop when either a healthy branch or no branch was introduced into the chamber. A similar experiment conducted in Montana using infected and healthy material sent to Montana from Mt. Storm failed to duplicate the syndrome. Conditions of transport were not indicated so there is no way to determine whether biological materials were made inviable during transport.

Pine needle bases damaged by the "causal agent" at Mt. Storm sometimes contained necrotic zones several cell layers thick, sometimes small wedge-shaped lesions 2 to 5 cells wide and 3 to 10 cells into the needle and sometimes random or localized penetration of the "causal agent" and ensuing tissue necrosis. Inoculation studies were conducted in Montana and the short needle syndrome apparently produced, but the results in Montana were not described in sufficient detail to determine similarity or dissimilarity to Mt. Storm damage. Available evidence does strongly indicate an absence of needle-base lesions on "acid" induced short needles but lesion presence on short needles of

diseased plants located in the field. It has also been found that spraying plants with insecticide or miticide prevented short needle syndrome development, a predictive condition which is consistent with the evidence indicating a biological causal agent for the observed damage.

The possibility of insects penetrating through the sheath surrounding the needle bases (fascicular sheath) and thus causing the damage attributed to "acid rain" was not considered in the Montana investigations. The fact that fascicular sheaths were removed prior to the initial killing and fixing of needles would prevent the investigator from determining by microscopic examination whether the causal agent had been inside or outside the sheath at the time localized cell masses were destroyed. This is contrary to the claim that the "causal agent" must be beneath the fascicular sheath. It is likely that the mouth parts of a small insect (mite) penetrated through the immature/ fascicle, inflicted damage and obtained nourishment. Then the insect may have gone on to another needle bundle. The experimental procedure as described would not rule out this possibility.

Acid inculation experiments on developing pine needles for 20 to 30 days in Montana are claimed to have produced a long-short needle syndrome with sulfuric acid (pH - - 4.0 to 4.5), hydrofluoric acid (pH - - 5.0 to 5.5) and nitric acid (pH - - 3.5 to 4.5). It is also claimed that higher pH (less acidic) treatmenst caused overall needle necrosis (death) and needle casting of scotch and white pine developing needles. However, other workers have been unable to duplicate and consequently verify these results. Field experiments using sulfuric acid

solutions of pH 1.7 to 2.7 resulted in needle yellowing or death but no short needles, less concentrated solutions of 3.7 and less had no apparent effects. Other studies have shown that weekly spraying of seven western conifer species for twelve months with sulfuric acid solutions ranging from pH 6 to pH 2 produced no observable effects. Additional studies conducted with white pine seedlings grown in a sandy loam soil and subjected to nitric acid simulated "acid rain" with pH ranges of 5.0 to 2.3 have demonstrated that after a 20-week treatment period, seedling productivity actually increased with increased acidity apparently from nitrogen fertilization. However, at pH 2.3, the soil was nearly depleted of potassium, magnesium and calcium. The fact that other scientists have been unable to duplicate the reported Montana long-short needle syndrome strongly indicates that a factor other than acid must have been responsible for this anomaly.

It has also been claimed that ponderosa pine trees in Montana prematurely cast older needles (third to fifth year growth) due to severe air pollution problems. The statement has been made as an example of this claim that ponderosa pines retain only 2 to 3 years of needle growth in a 4-mile radius around the Corette Power Plant in Billings, Montana. Personal observations of ponderosa pine trees in the same area indicated that needles are being retained for 5 to 8 years on all branches of young trees and on the terminal shoots of older trees. Lateral shoots of older trees are maintaining their leaves for 2 to 5 years. The same observations held true of ponderosa pines growing in areas south of East Helena, Montana; near

near Flesher Pass, 30 miles northwest of Helena on the Continental Divide; in the foothills of the Laramie Mountains near Casper, Wyoming; and in the foothills of the Rocky Mountains in the Canyon of the Poudre River, 30 miles west of Fort Collins, Colorado. These latter three places are located in areas which are not considered to be subject to identified sources of pollution and no significant difference in leaf retention was noted. Based on these observations, I find no justification for considering ponderosa pine to be subject to premature leaf abscission in those areas observed to be located near potential pollution sources or in areas generally considered to be pristine.

GASEOUS EFFLUENTS

Gaseous emissions from the Colstrip Electrical Generating Plant will include sulfur dioxide, nitrogen oxides, fluoride and mercury resulting from the combustion of coal.

Adverse reactions of vegetation, wildlife, domestic animals and man to these pollutants depend upon many factors including the sensitivity of the species to specific effluent concentrations, the period of exposure, relative humidity of the air, temperature, soil conditions, light intensity, time of day, physiological condition during the time of exposure and stage of development. Biological effects of effluents on vegetation may include decreased photosynthetic efficiency or tissue death (necrosis). The absolute concentrations resulting in growth impairment or tissue death vary widely from one species to another and from one effluent to another. Respiratory tissues of humans and wildlife appear most sensitive to atmospheric

effluents while eye tissues may also be affected. Excessive foliar uptake of gaseous effluents may result in damage symptoms which are visible and characteristic for each type of gas. Therefore, depending on the type, concentration and duration of exposure gaseous effluents may or may not produce visible damage to vegetation, wildlife, humans or domestic animals, however, such effects or the lack of them must be quantified in such a way that a definite statement may be made of "damage", "no injury" or "distinct benefit." Statistical tests provide a means of deciding whether an observed effect is important -- whether significant damage has occurred. For Biological work, an observed difference having a probability of 5 percent or less of occurring randomly is considered significant. Therefore, significant damage is defined as an economic loss definitely attributable to one or more of the gaseous effluents and having a statistical probability of 5 percent or less of occurring randomly.

My studies and an evaluation of studies conducted by others indicate that the concentrations of gaseous effluents from the Colstrip electrical generating units are not expected to produce significant damage to vegetation, wildlife, humans or domestic animals.

SULFUR DIOXIDE

At Colstrip, the highest calculated ground-level average SO_2 values equal 405 ug/m^3 (0.15 ppm) using the Pasquill model or 256 ug/m^3 (0.09 ppm) using MSU model. This represents an unusually high short-term condition. The maximum long-term annual average concentration for the four units will be about

1.4 ug/m^3 (0.0005 ppm), an extremely low ground-level concentrations. Neither short nor long-term exposures to calculated SO_2 concentrations from the Colstrip Electrical Generating Facilities are expected to produce significant effects in vegetation, wildlife, humans or domestic animals.

ACUTE EXPOSURES

Acute, short-term sulfur dioxide injury results from foliar absorption of toxic levels of SO_2; the SO_2 is readily converted to sulfite in the mesophyll cells where the reducing properties of sulfite deleteriously affect metabolic processes taking place in those cells. Acute injury in broad-leaved plants results in local spots of dead tissue on both upper and lower leaf surfaces which usually occur between veins and often are more prominent toward the leaf petiole. The affected tissues dry to a white or ivory color (that is, they become necrotic), while the surrounding leaf tissues remain green and functional. Fully expanded leaves are most sensitive to this type of SO_2 injury; the oldest leaves are moderately sensitive, while young leaves rarely are affected because they lack functioning gas exchange pores called stomates. In parrallel veined plants, such as grasses, lilies and gladioli, leaf tips and lengthwise areas between the main veins may show damage. In conifers, acute injury usually results in bright orange-red needle-tip damage to current year needles, often with a sharp line separating the damaged tips and the normally green bases.

Sulfur dioxide toxicity investigations have primarily been conducted in humid and subhumid regions. A recent EPA literature review concerning factors affecting plant sensitivity to sulfur

dioxide indicates that plants grown under conditions of low soil moisture and low humidity are much less susceptible to sulfur dioxide damage than those grown under moist conditions. Such a low soil moisture and low humidity condition is characteristic of southeastern Montana.

Even though a careful literature review indicates that high humidity and soil moisture are both required for maximum plant susceptibility to sulfur dioxide, the statement has been made regarding the Colstrip area that plants in dry climates suffer as much or more sulfur dioxide damage than those in wet climates. In support of that statement it has been mentioned that killing of vegetation in unseasonably dry years has been excessive as compared to wet years. This statement completely ignores a basic ecological fact that plants require a certain quantity of soil moisture in order to survive and that unusually dry years result in the killing of trees, a fact amply documented on the Great Plains.

Similar reference to the excess killing of vegetation resulting from the initial shock of a power plant going on line has been made. Based on gaseous concentration and time of exposure this "shock" will be much less than that experienced by plants in fumigation chambers. These chambers are standard tools used in assessing air pollutant effects under carefully controlled conditions. Plant specimens are placed into such chambers and are directly subjected to the conditions of interest, such as auto exhaust, sulfur dioxide, nitrogen dioxide, and so on, with no period of acclimation - a stress situation much more traumatic than the condition like an initial shock supposedly

occurring near new pollution sources. Such implied damage can only occur at toxic concentrations such as those which produce damage under equivalent controlled fumigation chamber conditions.

As additional evidence for the "excess killing" claims, it has been mentioned that Billings, Montana suffered a tremendous air load of phytotoxic emissions in 1970. The Montana Health and Environmental Sciences Implementation Plan for Control of Air Pollution in Montana has been cited as the authority in support of this statement. The implementation Plan lists the actual particulate and SO_2 emissions in 1970 in Billings and projects those emission rates to 1975 for the following major categories: Fuel Combustion, Industrial Processes, Solid Waste, Transportation, Miscellaneous and Total. The same categories for the Billings Air Quality Control Region were used in projecting emissions of particulates, SO_2, CO, HC and NO_x for the same years. The Implementation Plan does not refer to an increased air load of phytotoxic emissions near Billings nor does it present data suggesting that emissions in Billings have increased, decreased or stayed the same from preceeding years. Therefore, the implied evidence for "excess killing" near Billings is not supported by the reference cited.

Observations made by me and those working under my direction in areas around Billings, Montana and specifically in areas of major impact directly across from the J.E. Corette generating facility have indicated only slight injury to vegetation caused by sulfur dioxide. The sensitive specie, ponderosa pine, exhibited approximately 2 percent leaf tip necrosis caused by sulfur dioxide and this was not found to adversely affect annual

growth, leaf retention, seedling germination or population stability. There was no discernable difference in annual growth of these trees when comparing growing seasons before and during the power plant operation. At no time was any evidence of "excess killing" found to be substantiated. Here, the difference between superficial injury (2 percent leaf tip burn) and functional damage is important. There was no indication that the limited tip burn symptom had impaired the physiological function and growth of the trees. I have made similar observations at other fossil-fired power plants in both the western and eastern portion of the United States.

The "Handbook of Effects Assessment, Vegetation Damage" indicates that alfalfa (Medicago sativa) and barley (Hordeum vulgare) are two of the plant species most sensitive to sulfur dioxide. These species were observed to suffer some foliar necrosis (leaf tissue death) after two-hour exposures to 0.8 and 1.0 ppm, respectively, of sulfur dioxide although they showed no tissue damage after 2-hour exposures to the reduced levels of 0.2 and 0.3 ppm.

Plant species in the Colstrip area are no more sensitive and in the large majority of cases extremely more resistant to sulfur dioxide than alfalfa and barley and are not expected to be affected by short-term exposures to sulfur dioxide from Colstrip electrical generating emissions.

Turning to the available evidence on animals, the levels of sulfur dioxide required to produce toxic reactions are far in excess of any which will be produced by the Colstrip plant. A 20-minute exposure to 5 ppm of sulfur dioxide produced no

permanent effects in ten guinea pigs although temporary breathing difficulty (increased resistance to respiration air flow) was observed. No reports of acute sulfur dioxide-induced effect in wildlife, domestic livestock or humans at concentrations of less than 1 ppm were found. At no time should the levels of sulfur dioxide produced at Colstrip even significantly approach those levels required to induce toxic reactions in fauna or humans.

CHRONIC EXPOSURES

Long-term effluent effects will be reduced by air mass movements, precipitation and by active sorption of SO_2 and ozone by soil and sulfur dioxide by suspended particulate matter. Although most soil sorption of atmospheric SO_2 increases acidity of the soil surface in industrial regions, this is not expected to be a problem in the Colstrip areas because of the neutralizing effect of the basic (alkaline) soils present. Any lowering of the soil pH could actually prove to be beneficial to vegetative establishment in the area. Sulfur dioxide sorption by soils is independent of biota present, pH, organic matter content and particle sizes, but is greater for moist than for dry soil. Little sulfur dioxide-soil sorption is expected to take place in the semi-arid Colstrip area.

Chronic (long-term) sulfur dioxide injury to plants results from sulfate accumulation in foliar tissues and resultant toxicity. Such toxicity produces leaf chlorosis and reduced photosynthetic efficiency proportional to the extent of injury. Chinese elm, a tree species, developed severe chlorosis and necrosis when exposed to a sulfur dioxide concentration of 0.25

ppm for 30 continuous days, while Norway maple and ginkgo developed moderate marginal chlorosis at 0.50 ppm for 30 days. White pine trees exposed to 0.017 ppm SO_2 for 10 years near Sudbury in Ontario, Canada had 11 percent more foliage loss and slightly less wood produced annually per tree as compared to trees in an area 100 miles from the SO_2 source. White pine is the tree species most sensitive to SO_2 but does not occur in the western United States.

The effect of SO_2 on conifers very near smelters in the East Helena area was studied. Needles were collected from five conifer species in that area and analyzed for sulfur content; their sulfur content varied in proportion to levels of exposure to SO_2 during their active growing stage. Differences in sulfur uptake were also noted among the five species analyzed. In 1969, exposure of conifers to SO_2 was intentionally reduced by a smelter which operated at reduced levels when weather conditions indicated likely damage; sulfur levels in the conifer needles were found to be:

Common Name	Species	Sulfur Content, ppm
Ponderosa Pine	(Pinus ponderosa)	1400
Lodgepole Pine	(Pinus contorta)	1600-3000
Scotch Pine	(Pinus sylvestris)	1400-1900
Engelmann Spruce	(Picea engelmanni)	2800
Subalpine Fir	(Abies lasiocarpa)	1000

A concentration of about 1000 ppm is considered normal for most actively growing plants. The ranges observed in the noted conifer species are considered to be approximately normal.

My own observations of conifer species growing in the East Helena area have indicated similar conditions as already described for sulfur dioxide and acid precipitation evaluations

near the J.E. Corette plant in Billings. The gaseous effects on these species from industrial operation was not found to be detrimental to annual growth, establishment or overall vegetative vigor.

NITROGEN OXIDES

Various oxides of nitrogen are produced by the reaction of atmospheric nitrogen and oxygen in the coal-fired furnaces. Nitrogen dioxide is generally considered to be the most toxic of these.

The calculated annual average ground level concentration of NO_2 equals 1.7 ug/m^3 (0.0009 ppm). Neither short-nor long-term exposures to expected nitrogen oxide concentrations from the Colstrip facilities are expected to produce significant effects in vegetation, wildlife, humans or domestic animals.

ACUTE EXPOSURES

Acute nitrogen dioxide injury symptoms closely resemble sulfur dioxide injury, including collapse and bleaching to white or light tan of interveinal tissues. The apical portion of newly expanded leaf tissue or larger portions of successively older leaves are normally sensitive. Very young, expanding leaves or those 3 or 4 weeks old ususlly escape injury.

Most experimental fumigation experiments causing observable vegetative injury have been conducted with NO_2 concentrations exceeding those normally encountered in polluted atmospheres which contain less than 0.5 ppm of NO_2. Species sensitive to nitrogen dioxide such as the pinto bean (Phaseolus vulgaris), tomato (Lycopersicon esculentum) and cucumber (Cucumis sativus) may show signs of injury after a 2-hour exposure to 6 ppm

nitrogen dioxide when grown under a light intensity which is equivalent to full sunlight. Under an extremely low light regime (similar to a very cloudy day), these same plants may show injury after exposure for 2 hours to 2.5 to 3.0 ppm. My investigation has revealed no reports which indicate nitrogen dioxide acute damage to any plant tissues at concentrations of 1 ppm or less for less than one month. This concentration level which is needed to cause damage is more than 1000 times more concentrated than the maximum annual average which has been calculated for all four Colstrip units.

The effects of NO_2 on animals, including man, are mostly confined to the respiratory tract. Single exposures of mice to 2.5, 3.5, 5 and 15 ppm of NO_2 and subsequent exposure to pneumonia bacteria resulted in increased mortality at concentrations of 3.5 ppm and greater, but had no significant effect at 2.5 ppm. Higher concentrations resulted in pulmonary congestion in mice at 15 ppm and temporary mild pulmonary edema in rats and guinea pigs at 15 to 20 ppm. For humans, the odor threshold of NO_2 is considered to be 1 to 3 ppm. Nasal, eye and respiratory tract irritation in particularly sensitive subjects may result from exposure to 13 ppm NO_2. At NO_2 concentrations below 50 ppm, there is little evidence of pulmonary effects other than temporary discomfort.

Considering the levels of NO_2 which are required to cause acute effects in both plants and animals and comparing them to the expected level which will be produced as a result of the Colstrip plant operation, it is reasonable to conclude that no significant adverse effects are expected.

CHRONIC EFFECTS

The average background level of NO_2 for the non-urban North American Continent has been estimated by the EPA at about 0.004 ppm. This largely results from the photo-oxidation of biologically produced nitrogen oxide. Average background levels at Colstrip are estimated to be about 10 ug/m^3 (0.005 ppm) With full capacity operation of the Colstrip plant, the annual average NO_2 will be about 0.0009 ppm above the existing background levels.

Nitrogen dioxide (NO_2) is readily sorbed by moist soils and oxidized to nitrate, while nitric oxide (NO) and nitrous oxide (N_2O) are sorbed much more slowly. NO_x is readily converted to nitrate in which form plants may absorb it. Such conversion to nitrate may also occur in the atmosphere and fall in raindrops as already indicated.

Chronic effects resulted from continuous or intermittent animal exposures to levels of 5 ppm or lower. Direct tissue damage to bronchial epithelial cells of rats occurred with continuous exposure to 4 ppm for 20 weeks, and minor pulmonary changes occurred in guinea pigs with similar exposure to 5 ppm.

However, continuous exposure of mice to 0.5 ppm NO_2 in the presence of pneumonia bacteria for 3 months resulted in increased mortality. Second grade school children exposed to NO_2 levels of 0.083 ppm for more than 12 weeks had slightly decreased ventilatory performance as compared to the performance of children exposed to 0.063 and 0.043 ppm NO_2; the decreased performance was on the order of 0.01 to 0.02 liter. The maximum calculated NO_2 levels near the Colstrip Electric Generating Plant

operating at 100 percent capacity will be more than fifty times lower than the values for this study and are not expected to produce any significant adverse effects.

FLUORIDES

Fluorine is a common component of our natural enviornment. It exists in chemically combined forms and is thought to constitute 0.032 percent of the earth's crust with soil concentrations up to as much as 1 percent. Fluorine is also a normal constituent of water as well as foodstuffs. Cereal grains may normally contain from 2 to 5 ppm, leafy vegetables from 7 to 12 ppm, protein supplements from 10 to 30 ppm and some mineral supplements as much as 30,000 to 40,000 ppm. Since it is presently impossible to produce a fluorine-free diet, it is not possible to know if fluoride is a useful or essential component in animal and human metabolism.

When coal is burned, trace quantities of fluorides are emitted as particulates and as gaseous hydrogen fluoride (HF), silicon tetrafluoride (SiF_4), hydrofluorosilic acid (H_2SiF_6) and its salts. Calculations indicate that the maximum short-term (24-hour) ground-level concentration of gaseous fluorides will be 0.01 to 0.03 ppb, far below the state standard. The short-term Montana air quality standard is 1.0 ppb which the Department of Health and Environmental Science considers to be adequate.

Vegetation in the Colstrip vicinity sensitive to high fluoride levels consists of ponderosa pine, barley, yellow sweetclover, lilacs and violets. Of these, ponderosa pine is the most sensitive, and the remaining plants exhibit inter-

mediate sensitivity. Susceptibility data obtained from fumigation experiments indicate that the lowest fluoride concentration required to cause slight injury to the ponderosa pine after 7 to 9 days of continuous exposure is at least 0.8 ppb. This concentration is more than 25 to 80 times higher than the maximum short-term ground level concentration expected from the Colstrip plant.

Long-term accumulation of fluorides in vegetation must also be considered. Fumigation studies with gladiolus, fruit trees, barley, alfalfa and cotton indicate there is no invisible injury or reduction in apparent photosynthesis until the threshold level for obvious leaf burn is reached. Once this occurs, relationship between foliar damage and reduction in photosythetic capability is linear. That is, fluoride accumulation in perennial vegetation will not be detrimental until the threshold level is reached. The suggested level not to be exceeded for this type of vegetation is 0.5 ug/m^3 (0.665ppb). This figure may be safely doubled for forage crops. Maximum expected fluoride concentrations of 0.01-0.03 ppb are expected from the Colstrip electrical generating units.

The maximum tolerance level for man under 8-hour fumigation conditions is about 3 ppm.

A comparison of fluoride levels which show damaging effects in plants, animals or man with the projected maximum concentrations from the Colstrip plant indicate no adverse environmental impact from fluoride emissions.

MERCURY

The total mercury emissions from the Colstrip plant operat-

ing at 100 percent capacity feed rate will be approximately 90 percent of the trace amount contained in the coal,[100] but considerably less than one third of the 27.0 lb/day judged to be safe by the Environmental Protection Agency.[78] The total amount of mercury generated from coal combustion is calculated to be 3.94×10^{-1} lb/hr. Ninety percent of this (3.55×10^{-1} lb/hr) will be released via the stack; the remaining 10 percent (3.9×10^{-2} lb/hr) will remain in the fly ash. It is estimated that only 0.5 percent (1.95×10^{-4} lb/hr) of this fly ash will escape the scrubbers and be released to the atmosphere in particulate form. These quantities are minute and represent a negligible contribution to the environment. No adverse effect on vegetation, food chain components or water sources are expected to result from these trace emissions.

The lack of any federal or state standards for short and long-term mercury emissions from coal-fired power plants reflects the low degree of environmental concern associated with the minute concentrations released from this type of facility.

SYNERGISTIC EFFECTS AMONG GASES

Air pollutants may interact with one another, producing synergistic effects at concentrations lower than either one acting alone. The type and concentration of gases expected in the Colstrip area as a result of short and long-term plant operation are not expected to produce significant synergistic effects.

Nitrogen dioxide and naturally occurring or man-made organic compounds may reach photochemically, producing ozone (O_3), nitric oxide (NO) and free organic radicals (RO).[79] Sulfur

dioxide may photochemically react with oxygen (O_2) producing sulfur trioxide (SO_3) and ozone (O_3). Nitric oxide (NO), the primary nitrogen oxide product of high temperature fuel combustion, is rapidly reduced to NO_2 by ozone and after conversion of nearly all NO to NO_2, may result in formation of peroxyacetyl nitrate (PAN) and its homologues from free organic radicals (RO).

Ozone forms naturally from electrical discharge (lightning) potentially producing concentrations of 0.1 ug/m^3 (0.00005 ppm) and from solar radiation in the stratosphere at altitudes of 50,000 to 120,000 feet. Stratospheric ozone may be transferred to the lower atmosphere in the vicinity of the jet stream and in weather-frontal zones. Measurements of ozone in remote portions of the world range from 20 to 100 ug/m^3 (0.01 to 0.05 ppm). Ozone levels in the Colstrip area averaged 0.03 ppm as determined by continuous monitoring by personnel of the Montana State Department of Health and Environmental Sciences. This average is the mid-point between observed natural levels.

Exposure of Maryland Type 32 tobacco (Nicotiana tabacum) to 0.15 ppm of ozone for three hours resulted in damage to about one-third of the leaves, while exposure to 0.05 ppm for six hours resulted in average leaf damage of 5 to 10 percent. A combination of 0.10 and 0.50 ppm ozone and sulfur dioxide, respectively, for three hours resulted in greater leaf damage than with either gas alone. Other investigations have shown synergistic effects in alfalfa, broccoli, cabbage, radish, tomato and tobacco plants with minor leaf damage observed from 4 - hour concentrations of 0.10 ppm ozone and 0.10 ppm sulfur

dioxide.

Ozone levels are too low to produce synergistic effects with sulfur dioxide at present levels and will produce no significant synergistic effects when all four Colstrip Electrical Generating Units are operating. Higher SO_2 levels normally occur during inversion break-up in the morning while ozone levels normally increase during the early afternoon hours.

Possible synergism among NO_x and fluoride have also been considered. Expected gaseous concentrations are far too low to produce significant synergistic effects. For example, combinations of NO_x and ozone are slightly less toxic than ozone alone. Inversion break-up fumigation conditions (the time of maximum ground-level pollutant concentrations) occur when surface-air temperatures increase in the morning while high ozone levels occur in early afternoon. The expected concentration of HF (0.01 to 0.03) is far below levels known to produce significant synergistic effects with other gases mentioned above.

PARTICULATES

Particulate emissions from coal-fired power plants are of concern because of the potentially toxic nature of some trace elements contained in these particulates, the respiratory irritation which may result from particulate inhalation and the fact that gaseous and particulate emissions may interact producing effects at concentrations lower than either one alone.

Important Trace Elements in Particulates

Ten important trace elements have been selected for discussion to illustrate that no significant impact will result

from the Colstrip electrical generating units under expected plant operating conditions.

Trace impurities in coal are released during combustion and partially removed by Venturi scrubbers before the gases pass to the stack. Scrubbers differentially remove elements depending on their chemical properties and the type of scrubber system involved. Differential elemental removal efficiencies and particulate emissions were considered when calculating maximum particulate deposition levels. Projected particulate deposition rates for the area of maximum deposition 10 miles southeast of the Colstrip units are given in Table 1. The table includes levels of these elements in soils near Colstrip, projected deposition over the 40 year life of the Colstrip Power Plant, and expected annual deposition of trace elements on vegtation and ratios of the amount added to the amount in soil before operation. The assumption is conservatively made that in this period of 40 years all of the particulate deposition will mix with the top inch of soil and none will ever be washed away by rain or blown away by wind. The total amount deposited for any given element will not exceed a level 0.3 times greater than that already in the soil.

Projected compounds emitted depend on chemical characteristics of coal impurities, firing temperature, air flow rate, chemical constitutents in the scrubbers and numerous other factors. Compounds expected from the Colstrip units include fused silicates of iron, aluminum, calcium, and many others. Some volatile compounds will be deposited on the surface of these silicates probably as the oxide assuming the presence of

TABLE 1

COMPARISON OF TRACE ELEMENT PARTICULATE DEPOSITION
WITH BASELINE CONCENTRATION IN SOIL AT COLSTRIP, MONTANA

Element	Assumed Concentration* (ppm)	100% Capacity Feed Rate** (lbs/hr)	Percent Emitted*	100% Capacity Emission Rate** (lbs/hr)	Total Emissions (tons/40 yr., 65% Load Factor)+	Maximum Deposition After 40 Years (Δ) lb/acre	ppm	Amount Presently Existing in Top 1 Inch of 1 sq. ft. of Soil pounds	ppm	Ratio of Amount Deposited in 40 Yrs to Baseline Level in Top Inch Δ	Expected Annual Deposition on Vegetation lb/acre	ppm
Arsenic (As)	5	9.89	10	0.989	112.6	2.1×10^{-2}	8.4×10^{-2}	2.0×10^{-5}	3.0	0.028	5.2×10^{-5}	0.0
Barium (Ba)	325.0	642.0	5	32.1	3660.0	7.0×10^{-1}	2.8×10^{0}	7.9×10^{-5}	12.0	0.23	1.8×10^{-3}	1.0
Beryllium (Be)	0.5	0.989	5	0.049	5.58	1.1×10^{-3}	4.4×10^{-3}	9.4×10^{-4}	1.43	0.0031	2.8×10^{-6}	0.0
Cadmium (Cd)	0.2	0.394	10	0.0394	4.49	8.5×10^{-4}	3.4×10^{-3}	6.0×10^{-6}	1.0	0.0034	2.1×10^{-6}	0.0
Fluorine (F)	35.0	69.2	10	69.2	788.0	1.5×10^{-1}	6.0×10^{-1}	2.8×10^{-3}	432.0	0.0014	3.8×10^{-4}	0.2
Lead (Pb)	5.0	9.89	10	0.989	112.6	2.1×10^{-2}	8.4×10^{-2}	2.2×10^{-6}	0.34	0.25	5.2×10^{-5}	0.0
Mercury (Hg)	0.2	0.394	90	0.355	40.4	2.0×10^{-4}	8.0×10^{-4}	6.8×10^{-8}	0.014	0.077	5.0×10^{-7}	0.0
Molybdenum (Mo)	1.2	2.37	10	0.237	27.0	5.1×10^{-3}	2.0×10^{-2}	4.7×10^{-7}	0.072	0.28	1.3×10^{-5}	0.0
Selenium (Se)	1.0	1.98	10	0.198	22.5	1.1×10^{-4}	4.4×10^{-4}	3.0×10^{-6}	0.45	0.0010	2.8×10^{-7}	0.0
Strontium (Sr)	225.0	444.0	1	4.44	506.0	9.6×10^{-2}	3.8×10^{-1}	4.3×10^{-5}	6.6	0.058	2.4×10^{-4}	0.0

* Source, DNR Exhibit 123

** Source, DNR Exhibit 123, calculated for all 4 units; assumes 700 MW each for Units 3 & 4 and 330 MW each for Units 1 & 2.

+ Load factor of 65% predicted for 40 year expected life of Colstrip Generating Units

Δ Numbers calculated were for the area of maximum deposition with no dilution from leaching or loss from wind or water erosion (total accumulation). Assumes deposited particulates become mixed with top inch of soil.

ΔΔ PPM = parts per million (weight/weight); assumes 2×10^{6} lb of soil/(acre) (6 inch depth)

excess air in the combustion chamber; arsenic, beryllium lead and molybdenum will probably be emitted in this form. Fluoride will be emitted as the fluosilicate primarily but partly as cadmium fluoride. Mercury and selenium will probably be emitted as the free metal primarily; a small proportion may be combined as the oxide. Barium and strontium very likely will be emitted as the sulfate and as oxides dissolved in inert silicates (i.e., as a glass).

The deposited compounds and metals will probably be converted to very insoluble compounds in Colstrip area soils and have no significant effect on plant uptake. A portion of the deposited particulate matter will remain on vegetation and be available for animal consumption during the year. Estimates of the amount accumulated during a year (in parts per million) are calculated for each element (Table 1). Additionally, these particulate matter accumulations are compared with the lowest levels known to produce an effect in animals.

ARSENIC

Arsenic particulate emissions will increase soil concentrations of the element by 2.8 percent in forty years, an insignificant amount. Arsenate becomes strongly sorbed onto a clay minerals and iron compounds severely restricting its movement within a soil. Approximately 0.03 ppm will accumulate on vegetation annually and be available for animal consumption. Horses and cattle can ingest approximately 20 to 30 grains of arsenic daily for many years with no apparent ill effects; this ingestion rate corresponds to approximately 1,000 ppm daily. Atmospheric concentrations lower than 200 ug/m^3 of arsenic are

considered safe for longterm human exposure. See (87) Both deposition on vegetation and atmospheric particulate levels are considerably lower than the lowest levels known to damage animals; therefore arsenic emissions will not have an adverse environmental impact on the area of maximum deposition.

BARIUM

Barium emissions will increase soil concentrations of the element by 23 percent over the 40 year power plant life. The expected compound emitted -- barium sulfate -- is nontoxic to plants and animals. (88) Approximately 1.0 ppm are expected to accumulate on vegetation annually, and since the compound emitted is nontoxic, no significant impact is expected.

BERYLLIUM

Beryllium emissions will increase soil concentrations of this element by 0.003 percent in the area of maximum deposition during the 40-year life of the Colstrip units. Annual deposition will result in accumulation of 0.002 ppm on local vegetation. Animal consumption of vegetation containing such a low concentration will produce no significant effect. Inhalation experiments have shown that effects resulted from mechanical interference with lung function rather than any specific toxic effect of beryllium; inhalation of 1000 ug/m^3 was nontoxic to animals. (86) For comparison, the maximum expected air level concentration of beryllium is 6.7 x 10^{-6} ug/m^3 with all four Colstrip units operating.

Beryllium accumulation in soil should have no effect on plants growing there or on animals consuming these plants. Beryllium oxide, the expected effluent, is extremely insoluble and probably will remain as this compound in soils. The lowest soil solution concentration which has been shown to produce an

effect on plants is 1 ppm. The expected soil solution concentration near Colstrip will be only 0.01 ppm or 1 percent of that. Therefore, considering the low solubility and low toxicity of beryllium, I conclude that beryllium emissions will produce no significant impact.

CADMIUM

Cadmium emissions during the 40-year life of the Colstrip units will result in 0.34 percent more of this element in the area of maximum deposition. Cadmium will likely be converted to the carbonate in Colstrip area soils due to the extremely insoluble nature of the carbonate and due to the abundance of carbonate ions locally. Annual deposition on vegetation will equal 0.001 ppm.

Relatively little is known about cadmium toxicity levels. The lowest level known to affect mammals exceeds 5 ppm. A level of 5 ppm in drinking water had no affect on rat or mice growth or general health. Levels less than one thousandth as great are not expected to produce any adverse effect on wildlife or domestic animals near Colstrip; therefore, cadmium is not considered to produce a significant impact.

FLUORIDE

Particulate fluoride releases during the forty year life of the Colstrip units will increase soil concentrations of this element by 0.2 percent. The amount of soluble fluoride available for plant uptake will not be affected by the small amount added. Therefore concentrations of fluoride in plants will not be affected by absorption from soil.

Annual particulate effluents will result in deposition of

0.2 ppm on the surface of vegetation in the area of maximum impact. Cattle, the domestic animal most sensitive to fluoride, can safely ingest forage containing up to 35 ppm. Preliminary background levels of fluoride determined in the Colstrip vicinity are low in annual and perennial vegetation and wildlife. Slightly higher fluoride levels were found in mice femurs, but the sample size (17 total) is too small to be statistically significant.

Most animals are better able to tolerate fluorides in greater quantities than cattle. With carnivorous animals, fluoride transfer through the food chain is not a problem. Fluoride is largely accumulated in the bones and teeth of animals and unless these parts are ingested, a significant transfer of fluoride is not possible.

It has been mentioned that a calculated 17.9 tons of fluoride will be emitted annually from Colstrip Units 1 through 4, but no indication was given as to how much fluoride is projected to occur at ground level and whether these expected concentrations will have a significant effect. Instead the fluoride content of fly ash from the Four Corners Power Plant in New Mexico, fluoride content of vegetation and fauna near the Corette Power Plant in Billings, ecological studies near Anaconda and air pollution studies near a rock phosphate concentrating plant in Hall, Montana has been emphasized. It has been incorrectly implied that the Corette Power Plant in Billings was responsible for high fluoride levels near Billings.

A careful study of air pollutants in and around the cities of Billings and Laurel in Yellowstone County, Montana included 1964 samples and 8998 hours of continuous samples; 450 atmospheric

fluoride and 450 vegetation fluoride samples were collected and analyzed. That study summarized responsibility for atmospheric fluoride as follows: "Data from the Laurel area makes it painfully apparent that fluoride levels are directly attributable to refinery operations in both the Billings and Laurel areas." The fluoride-in-forage samples correspond to atmospheric distribution patterns. The Yellowstone County study does not even mention the Corette Power Plant as being mainly or even partly responsible for high fluoride levels near Billings.

Since the Corette Power Plant in Billings is not, and I repeat <u>not</u>, responsible for the high fluoride levels near Billings, the entire argument, indicting power plants as being responsible for fluoride damage to vegetation and animals, becomes much less important.

An example used to compare the Colstrip power plant units with the Cominco American Phosphate Rock concentrating plant in Hall, Montana suffers from the problem of comparing unrealistically different fluoride quantities emitted. According to the example the Cominco American phosphate plant emitted 2500 tons of fluoride annually from 1963 to October 1968. Vegetation near the phosphate concentrating plant contained a thick coating of fluoroapatite mineral dust and the dust was apparently remaining on the tissue surface rather than being assimilated by plants. Vegetative collections in 1969 after plant shut-down contained very low fluoride levels (less than 40 ppm for most new-growth samples) indicating that very little fluoride was absorbed through plant roots.

The 2500 tons of fluoride annually emitted by the phosphate

concentrating plant sharply contrast with the approximately 17.9 tons emitted annually from all four Colstrip electrical generating units. The phosphate concentrating plant emitted more than 200 times more fluoride annually than will all four Colstrip units operating at full capacity based on this calculated tonnage. Ecological effects near the phosphate plant are not in any reasonable way comparable to those near the Colstrip units.

Additionally, the comparisons between Billings and Laurel and the Colstrip units are not valid because the Colstrip units have tall stacks which will disperse effluents over a wide geographical area while emissions in the Billings area were from low stacks or ground level and dispersed by surface air flow. Even though such a comparison is not valid, no reports of fluoride damage near either Billings or Laurel were received even though local veterinarians were requested to notify the Yellowstone County Air Pollution Control Agency of symptoms of fluorosis in the area.

LEAD

Soil lead concentrations in the area of maximum deposition will be increased by 25 percent in 40 years, an insignificant amount. Annual deposition on vegetation will increase the lead content of forage by 0.03 ppm. Cattle can safely ingest 1 to 2 g of lead daily for over two years without ill effects; horses may consume as much as 500 to 700 g before suffering toxicity effects. To obtain these amounts by feeding on forage in the maximum impact area near Colstrip, cattle would have to ingest approximately 2×10^5 tons of forage daily and horses would have to ingest approximately 8×10^7 tons of this forage. Individual animals

impact annually. Concentrations of 20 ppm and greater on vegetation are toxic to cattle; however, horses are unaffected even at these levels. Expected molybdenum concentrations will not produce any significant impact to fauna and may benefit vegetation growing in the Colstrip area.

SELENIUM

Selenium will probably be emitted as the metal and converted to the selenate salt in alkaline soils. Emissions of this element will increase selenium concentrations of soil in the area of maximum deposition by 0.10 percent in 40 years. Particulate deposition on vegetation will result in annual accumulations of 0.0002 ppm. Selenium is an essential dietary nutrient for animals and perhaps is essential for humans as well. Certain western plants such as Astragalus (many but not all species), woody aster (Xylorrhiza), goldenweed (Oonopsis) and prince's plume (Stanleya) require selenium as a nutrient element and accumulate as much as 15,000 ppm. Other species such as Aster, Atriplex, Sideranthus and Machaeranthera accumulate selenium on soils containing high concentrations of this element; these species become unpalatable to grazing animals when they contain high selenium concentrations. Expected selenium concentrations in soils and plants will not be toxic to or impalatable for domestic and wild animals.

STRONTIUM

Strontium emissions will increase soil concentrations of this element in the area of maximum deposition by 5.8 percent in forty years. The element will probably be converted to the very insoluble carbonate in Colstrip soil. Annual deposition of this

cannot possibly consume such quantities. Therefore, lead emissions are not considered to produce a significant impact.

MERCURY

Mercury emissions will result in a 7.7 percent increase of this element in the area of maximum deposition during the forty year life of the Colstrip electrical generating units. Annual deposition on vegetation will result in accumulations of 0.0003 ppm. Expected emissions, when assuming that mercury gas will condense onto particulates doubling their mercury content, will equal approximately 9.0×10^{-4} ug/m^3. Sheep and cattle can safely tolerate 0.6 mg/m^3, which equals 600 ug/m^3. Roses, the most sensitive plant species considered, may be damaged by mercury concentrations of 10 ug/m^3. On the basis that the expected emission concentrations are approximately 10,000 times lower than those producing any toxic effects, mercury emissions are not expected to produce any significant impact on the environment.

MOLYBDENUM

Molybdenum, an element required for plant growth, will be deposited in the area of maximum deposition over 40 years such that soil levels will increase by 25 percent. Molybdenum exists in soils in the form of molybdate salts and as sulfide is required in only extremely low soil solution concentrations; 0.01 to 0.02 ppm. Deficiency of this element is common in acid soils, but toxicity is found only in neutral soils containing 10 ppm or more of the element. Plants normally contain approximately 0.1 ppm. Particulate deposition (mostly insoluble) on vegetation will result in 0.008 ppm accumulating in the area of maximum

element on vegetation will result in accumulations of 2.0 ppm. Since strontium is chemically similar to calcium and functions the same, as in bones for example and since strontium and calcium are so similar biologically, no significant impact is expected at these low levels.

SYNERGISTIC EFFECTS BETWEEN PARTICULATES AND GASES

The maximum calculated 24-hour ground-level quantity of particulate matter (5.9 ug/m^3) is insignificant when compared to typical deposition rates of dustfall. Typical values for dustfall in urban areas range from 31.25 lb/acre/month to 312.5 lb/acre/month. On a per-acre basis; the State of Montana's particulate deposition standard is 46.88 lb/acre/month.

Adverse physiological responses are often associated with the loading of the pulmonary alveoli with the medium to fine particulates which characterize the Colstrip fly ash. Penetration of particulates through the alveolar membrane into the parenchyma tissue of the lung is associated with the smaller of these particles. The adsorption or absorption of effluent or atmospheric gases and solutes by solid particulates may increase their irritability.

The maximum concentrations of particulates from full-load plant operation will be less than the normal background atmospheric dust and no adverse physiological effects are anticipated. Synergistic responses with inert aerosols and other pollutants such as SO_2 have been identified, but these effects are associated with very sensitive "reactor animals" exposed to high experimental concentrations (in excess of 20 ppm SO_2). Other toxic interactions between particulate matter and gases occur at

particulate concentrations greater than 1000 ppm.

CONCLUSIONS

Based on a careful, exhaustive and comparative review of the available literature, personal discussions with internationally recognized experts in the field of biotic effects of air pollution and my own field investigations relating to the effects of fossil fired electrical generating plant emissions on biota, I have reached the following conclusions related to the estimated biological impact associated with the Colstrip plant operation.

- No acid precipitation is expected to develop as a consequence of plant operation and no significant change in precipitation pH is expected to occur during the 40 year projected life of the plant.
- Expected gaseous emissions concentrations of sulfur dioxide, nitrogen oxides, fluorides and mercury from the Colstrip Plant is not expected to adversely affect vegetation or fauna. Short- and long-term gaseous emission concentrations will be lower than those known to injure plants or animals either directly or by acting synergistically.
- Particulate deposition of trace elements under normal plant operation will not result in toxic accumulations of trace elements in local soils. Estimated quantities of particulates released during normal plant operation, deposited on local vegetation and ingested by free-ranging wildlife and domestic animals will be lower than concentrations known to harm these animals.

EXAMINATION OF DR. PETER R. EDMONDS

Cross, by Department of Natural Resources and Conservation

By Mr. Sheridan:

Q Dr. Edmonds, have you been giving your statements out to the press?

MR. PETERSON: May the record show with regard to that comment that we have been, at the request of the press, furnishing them copies of written statements of witnesses which we anticipate will testify on the day those statements are given. When the statement was given to the Associated Press representative by me, I gave him the statements of Mr. Coldiron and Mr. Edmonds on the basis that those two gentlemen would testify yesterday. This was a courtesy requested by the press.

Q Dr. Edmonds, will you answer my question?

A Would you repeat your question, please?

Q Did you give your statement to the press?

A I did not.

Q Did you interview the press?

A I did not.

Q How was it the press reports you testified yesterday in both the Great Falls Tribune and the Helena paper?

A I have no knowledge as to that.

Q Before we get started, Dr. Edmonds, I want to establish a couple of ground rules with you. First of all, your opinions contained in your statement pertain not to just 3 & 4, but they include also the combined effect of Colstrip units 1, 2, 3 & 4, am I correct?

A In some instances I have considered the total impact. I have specified in some areas just 3 & 4, and in a number of cases I have specified over long term periods what I estimate to be the entire impact of the total operation.

Q Well, Doctor, when you have a qualified opinion anywhere in your statement today, when I'm asking you questions I would like for you to draw to my attention when that opinion is so qualified, because I don't want to mislead the Board into believing that some of your opinions are cumulative for the combined effects of 1, 2, 3 and 4, when only they are meant to imply to 3 & 4; understood?

A Yes.

Q Let's go to page 16 of your statement and talk a little bit about confidence levels. Starting at line 11, page 16, you make the statement, "For Biological work, an observed difference having a probability of 5 percent or less of occurring randomly is considered significant." Do you consider when giving opinions as a scientist that you are at the 95% confidence level throughout this statement?

A I consider that the 95% confidence level is the normal level associated with credibility in the biological sense.

Q Is that the normal level which you have used throughout this statement?

A That is the level that I have presumed to be used by the sources of information that I have used in this statement.

Q So the opinions you have in your statement you have 95% confidence in, is that right, in all aspects?

A The opinions I have in the statement are those opinions which

I believe to be correct for the situation at hand; yes, sir.

Q That's 95% right?

A The opinions that I expressed in this particular testimony are not the kind of situation where you can have that particular type of confidence. This confidence level is the level normally expressed for scientific studies where you have precise measurements that are taken.

Q And those are the scientific studies that you quote?

A That's correct.

Q Does that also include your own work?

A I didn't hear that.

Q Does that also include your own work?

A It depends on what particular work you are referring to.

Q Well, we'll go through them one by one and find out just what you did.

A Fine.

Q Dr. Edmonds, what research have you personally conducted on damage to vegetation, plants or animals over the long term from emissions from coal-fired generating facilities?

A Would you explain what you mean, please, by "long term"?

Q In excess of one year, Doctor.

A Are you referring to my studies or to the effect of air pollution?

Q I am referring to your research.

A I have been involved with the estimation of effects of air pollutants from coal-fired power plants for a period since 1972.

Q Doctor, I will ask you once again. Have you personally

conducted any studies of long term damage, other than a literature search, concerning the effects upon vegetation, plants or animals from a coal-fired generating facility?

A Yes, I have.

Q Doctor, do you remember when your deposition was taken at Pittsburgh?

A Yes, I do.

Q When was that taken?

A I believe it was in March of 1975.

Q March 27th, 1975. Your attorney, Mr. Bellingham, was there, and several attorneys from the opponents to the application were present; do you recall that?

A Yes.

Q Do you have a copy of your deposition?

A I do.

Q I will ask you, Doctor, if the following questions were made and the following answers were given. Page 78 -- let's go to page 79, it will be easier. Page 79, line 8: "Question: Have you personally conducted any studies of long term damage as thus defined to vegetation, plants or animals?" "Answer: What kinds of studies are you referring to, field studies?" "Yes, empirical studies, Doctor, of anything." "Answer: Literature search, review of the data and state of the art studies." "Question: I am excluding literature. I am talking about your personal, empirical research." "Answer: No, I have not." I go on, I say, "Why don't you finish the the answer so the record has a -- have you personally conducted any empirical studies of long term damage to vegetation,

plants or animals, as we just finished describing long term damage?" "Answer: No, I have not." "Question: From emissions from coal-fired power plants?" "No." "Your answer is no?" "Answer: That is correct." Did you give those answers to those questions?

A Yes, I did.

Q So you haven't done any personal, empirical research over the long term concerning the effects of air pollutants of coal-fired generating plants upon vegetation, plants or animals, have you?

A That is not correct.

Q So you were wrong and you didn't tell the truth when your deposition was taken in March of 1975?

A At the time the deposition was taken in 1975 I told the truth. Since that time I have done studies on the long term effects.

Q Doctor, your deposition was taken March 27th, 1975. You just told me now 1972. That's a little inconsistent, isn't it?

A I said at the time of the depositions that I had not done any field work, specifically field work relating to long term effects.

Q Doctor, do you want to look at page 28 again, in your deposition?

A Yes, I will.

Q It says "empirical research," doesn't it, Doctor?

A Yes, it does, and my answer at that time was no. My answer now is yes.

Q But you haven't done that since 1972, you've only done it subsequent to March 27, 1975, isn't that true, Doctor?

A That is correct, for field work specifically.
Q Can you tell me why --
A I'd like to complete my answer, please. Since '72 I've done extensive work in literature review and field observation, but not what I would consider empirical research. Since the time of the deposition I have done research in the field.
Q Let's go through your long term study, Doctor. Where was it?
A When you say "long term study," I'd like you to clarify specifically what you mean by long term.
Q I mean one year. We just answered about five minutes ago, to my question asking you for a definition of what long and short term was, you said, "What is long term?" and I told you a year. It still is one year, Doctor.
A By long term effects, I mean studying the long term effects that are obvious in the field, due to air pollution. In other words, longer than one year, resulting in effects of vegetation damage. Now, when you say "long term" you're referring to my studying -- length of time of studies. There's a difference between the two.
Q All right, Doctor, have you ever made a study for more than one year?
A No, I have not. I would like to qualify that with the specification that the studies that you are referring to, are the specific, empirical field work.
Q What's that?
A Taking detailed statistical measurements of air pollution damage in the field for a period of over one year.
Q You've never done that?

A No, I have not.
Q What's your longest short term study?
A Approximately one-half a year.
Q Where?
A That would be here in Montana, in Wyoming, in Colorado, and in Illinois.
Q What field studies did you run here in Montana, Doctor, yourself?
A Myself, I've continued the basic observations that I had been making around the J. E. Corette plant since 1972, only now I am trying to quantify the results of those observations.
Q Have you quantified those results?
A In part, yes.
Q You started in 1972?
A I began making observations in 1972, yes.
Q Did you collect records in 1972?
A I'm sorry; I'd like to change that date to '73.
Q Did you collect records in 1973?
A I made notations as to observations in 1973, yes.
Q So you're recording observations, not any tests; is that right?
A I think that has been made clear by my previous statements.
Q Where around the J. E. Corette plant were you making your observations?
A I have made observations throughout the periphery of the Billings area, specifically for the J. E. Corette plant on the ranges opposite the plant across the river.
Q Did you establish test plots?
A No, I did not.

Q This is another one of these windshield surveys?
A Would you repeat that, please?
Q This is another one of these windshield surveys, like Dr. Beisel makes?
A I'm afraid that I don't understand your question.
Q What did you do, drive around in a car and look at trees?
A No, I did not.
Q Walk around, then, and look at trees?
A I walked around and measured trees.
Q What did you measure, Doctor?
A I measured the difference in annual growth from year to year on the ponderosa pine trees, and made collections of vegetation for ponderosa pine, as well herbaceous vegetation in the area.
Q Tell me about your growth study, Doctor, for ponderosa pines.
A The growth study that I conducted there was for differences in annual growth for a ponderosa pine that had been growing there since before the time of plant operation, as well as new growth that has become established since the time of plant operation. The measurements that I took were to see if there was any measurable difference that I could ascertain between the annual growth of these pine trees before plant operation as well as after.
Q Where are the trees now, Doctor?
A They are still there.
Q Are they marked?
A No, they are not.
Q How many trees did you count, Doctor?

A As I recall, it was a small amount more than 100; I believe 105.
Q Did you put markings on those trees?
A No, I did not.
Q How did you go back and determine whether or not they'd grown in the last year?
A At the time I did the measurements I determined growth for that year, as well as prior growth since the trees were established.
Q You never went back to look? You'd never seen that tree before and you just went out there and looked at the bud and decided, "Well, it's grown this much in the last year," is that right?
A As I indicated I have been making observations in that area since 1973.
Q How many observations did you make on a tree -- or measurements, per tree?
A I measured all of the internodes on trees up to 8 feet high; on trees higher than that I made visual estimations.
Q Where are your figures on each measurement, Doctor?
A They are back in Pittsburgh.
Q What were your studies in Wyoming, Doctor?
A Similar type studies.
Q You walked around and made observations?
A No, I walked around and made measurements.
Q Of what type trees?
A Ponderosa pine.
Q How many trees in Wyoming did you take a look at?

A Approximately 100.
Q In what radius from the plant?
A A radius from half a mile to 3 miles, but the studies were concentrated in areas that were considered to be those areas of primary deposition and primary impact.
Q How did you measure leaf retention?
A Leaf retention was measured by making a notation as to how long leaves were retained on the trees, for what period of time or how many years they were retained on the lateral as well as terminal branches.
Q And did you do that around the Corette plant?
A Yes, I did.
Q What is the percent needle retention?
A Would you repeat your question?
Q What is the percent needle retention that you observed?
A I don't recall a specific percentage. I do recall that the average retention of the leaves there on lateral branches was from 3 to 5 years.
Q What percent is that for each year that you looked, Doctor?
A I'm not sure I understand your question.
Q What percent needle retention did you observe around the J. E. Corette plant in each year since 1973?
A I didn't hear a word you said. Rephrase your question, please.
Q What percent needle retention did you observe around the J. E. Corette plant in each year since 1973?
A I don't have those figures at hand.
Q Did you do it?
A I don't recall whether actual percentage was figured, but

that would be an easy number to obtain from the data that I have obtained.

Q Before you came to the J. E. Corette plant area in Billings to take a look at ponderosa pine trees had you ever studied ponderosa pine trees in the Northwest?

A No, I had not.

Q Can you measure needle retention, Doctor, without the internode?

A Do you mean can you distinguish whether needles have been retained for a specific period of years without looking to see whether they are associated with a specific internode?

Q No. What I'm asking you is how many needles were cast for given internodes for any year?

A Now, what is your question?

Q That's it.

A Will you repeat it again, please, because I didn't understand.

Q How many needles are cast for any given internode in any year?

A How many needles are cast for any given internode for any given year? Is that your question?

Q Right.

A That question doesn't make any sense to me at all. Are you asking me if it's possible to determine how many are cast?

Q How can you determine needle retention without it?

A Simply by looking at the leaf scar on the internode and counting the number of leaf scars or retained leaves.

Q If there's only a scar, Doctor, is that needle retention or not?

A If there's a scar without the needle being present, of course,

that is not retention. The scar is an indication, then, that a leaf has been dropped.

Q How can you tell the difference between the scar of a needle and a staminate cone?

A And a staminate cone?

Q Scar.

A The scar left from staminate cones are much larger than those that would be left from needles. Also, their specific location on the branch would indicate where they came from.

Q Now, Doctor, on your statement on page 1 you tell us about your interdisciplinary assessments of impacts associated with major projects in Montana, Wyoming, Arizona, Colorado, and several other states. When did you receive your Ph.D.?

A When?

Q Yes.

A In 1972.

Q And then you joined Westinghouse, right?

A That is correct.

Q Prior to that time you had no experience, had you, with the effects of pollutants from coal-fired generation facilities?

A That depends on what you mean by experience.

Q Had you had any field experience, Doctor?

A None, other than that associated with my normal course of course work.

Q That's book work, right?

A Book work as well as laboratory work.

Q What laboratory experiments did you conduct concerning the effects of SO_2 upon conifers while at school?

A There were laboratory trips to areas in southern New Jersey associated with the effects of air pollution in general, during which time the effects of SO_2 were covered.

Q You conducted laboratory experiments, Doctor, or did you just go in a laboratory class?

A These were in, as I indicated prior to this, a laboratory class.

Q You never prior to your graduation conducted any laboratory controlled experiments on the effects of pollutants upon conifers, did you?

A Not other than those associated with laboratory and field work.

Q What project are you taking a look at in Wyoming?

A The Wyoming project is associated with the Dave Johnson plant in Casper.

Q And Westinghouse is writing a report for them?

A No, this is associated with my own internal project in Westinghouse, a strategic project.

Q What's a strategic project?

A Strategic projects are common in the Westinghouse Environmental Systems department where individuals have the opportunity to conduct their own experiments. They are funded by Westinghouse in order to find more information about a particular subject that we would be interested in.

Q Is that true for the other states of Arizona?

A What do you mean, true for the other states?

Q Is there a Westinghouse funded project there, too?

A No. My work in Arizona was associated with specific projects.

Q For power companies, right?
A That is correct.
Q Which one?
A In Arizona I had specific association with the Environmental Impact Statements associated with the Four Corners Plant -- some work done in Arizona for that in relationship to it.
Q Just so we're not misleading the Board, Doctor, as of March of 1975 you had never visited the Four Corners plant site, had you?
A That is correct.
Q How about Colorado?
A The reference in Colorado is specifically to the Dave Johnson plant.
Q Who were you working for there?
A I was working for Westinghouse Environmental Systems, as I indicated previously.
Q What about Oklahoma?
A Oklahoma, the work associated there is specific to estimating the impact of a highway project.
Q You're not involved with pollutants there, are you?
A That's not entirely correct. I'm involved with the pollutants associated with the highway.
Q Not SO_2?
A Not specifically, other than the levels of SO_2 that would be present from the stationary sources in the area.
Q What stationary sources?
A There are some power plants in the area.
Q You are not making your investigation there on sites specific

to those power plants, though, are you?

A No, I'm not, they're general studies in relationship to the highway corridor.

Q What about South Carolina?

A South Carolina, the work there is associated with a nuclear fuels refabrication plant.

Q That doesn't have anything to do with coal-fired generating, does it?

A No, it does not.

Q How about Illinois?

A Illinois, the work there is associated with the evaluation of strip mining Braidwood, Illinois nuclear site; the evaluation of the environmental effects associated with the development of that site for nuclear production; and for the same utility, an evaluation of specifically the effects of SO_2 on sensitive species within the area of a coal-fired power plant.

Q Is there a coal-fired plant operating there now?

A Yes, there is.

Q How long has it been in operation?

A I believe it's been in operation since 1960.

Q When did you start working on that?

A As I recall, work began some time in late summer of this year.

Q How about Pennsylvania?

A Pennsylvania, work is associated with strip mining activity.

Q Not coal-fired generating facilities?

A That is correct.

Q How about New Jersey?

A New Jersey was work that was associated with the TOKAMAC

toroidal reactor at Princeton University.

Q That's a nuclear plant, right?

A It is a nuclear experimental fusion facility.

Q Not coal-fired generating?

A That is correct.

Q And Wisconsin?

A Wisconsin, the work there was associated with the environmental impact of oil fired peaking plants.

Q Well, Doctor, let's talk about those states in which you're doing projects concerning the effects of coal-fired generating facilities. That's Montana, Wyoming, Arizona -- right?

A No, I would not say Arizona.

Q Okay.

A I would say Colorado.

Q Not Oklahoma?

A No, not Oklahoma.

Q South Carolina?

A No.

Q Illinois?

A Yes.

Q Pennsylvania?

A No.

Q New Jersey?

A No.

Q Tennessee?

A No.

Q Wisconsin?

A No. I would like to state, though, that the particular

reference here on page 1, my association and activities within all of these states, as listed, is simply stated there as a reference to the states that I've had experience in evaluating the environmental impacts of major projects. That is my job.

Q Do you do anything else besides what you have listed here? For these states?

A How do you mean?

Q Well, do you have any other responsibilities for Westinghouse?

A My responsibilities at Westinghouse are as manager of the Terrestrial Systems group.

Q You write reports?

A In part. I evaluate the information in those reports and information that is being conducted by those working on them.

Q Do you have your own laboratory back there?

A (Answer unclear)

Q Have you ever conducted histological studies on any specimens taken from the State of Montana?

A No, I have not.

Q For the record, what's a histological study?

A A histological study would be a study involved with the evaluation of tissues of whatever biological specimen you happen to be working with.

Q And it's true, Doctor, that by studying histological samples, particularly in long needled species, you are able to determine whether or not there has been damage occasioned by exposure to phytotoxic gases?

A I think that depends on what specific studies you do, how

you do them, and whether you have enough samples to be able to indicate that what you're looking at is indeed the specific consequence of that.

Q Well, I understand that just about any experiment in the world that you run has certain qualifications, but that's the intent, isn't it, Doctor, of a histological study?

A That is the intent, and with the histological studies, I believe that if they are conducted properly, making the proper qualifications that you indicated, that they would give an indication of possible air pollution.

Q You've never conducted histological studies, have you?

A No, I have not specifically related to air pollution effects.

Q Let's take Montana, now, again, and I'll ask you, Doctor, what chemical analysis you have subjected samples taken by you of growing species to that are exposed to pollutants of an SO_2, NOx nature?

A Specific to Montana?

Q Yes.

A None.

Q You haven't taken any chemical analysis?

A That is correct.

Q No chemical analysis around Colstrip, no histological studies around Colstrip?

A I have stated that I have not taken any chemical analyses.

Q Have you made any chemical analysis of samples taken in Wyoming, Colorado or Illinois?

A Chemical analyses are being taken in Illinois.

Q When did you start that?

A They are just being initiated.
Q When's that? Now?
A As of last week.
Q Well, you really aren't too far along there, are you?
A This work is being done -- the actual chemical analyses are being done under my direction, and to the best of my knowledge that is when it was initiated.
Q Of course, you haven't done any chemical analyses of any samplings in any of these states before?
A That is correct.
Q Now, you've already told me that you did not establish any test plots in the Billings area for purposes of measuring or evaluating the effects of pollutants upon growing species?
A No, I did not establish any permanent plots. I did walk line transects.
Q And you didn't mark any of those trees, those pines?
A The plots were not permanent so they were not marked.
Q So when you come out here on one of your tours to your various test sites in the states of Montana, Wyoming, Arizona, Colorado, Oklahoma, South Carolina, Illinois, Pennsylvania, New Jersey, Tennessee or Wisconsin, how do you keep track of where the bushes are?
A That depends on what particular study you are talking about, and in all of those states that you have mentioned, including Montana, for those studies that I have done or have had others conduct under my direction, there were many permanent plots established for those particular studies.
Q But none in Montana?

A I am simply saying that in the one opposite the J. E. Corette plant, when I did my studies there, or initiated my studies there, I did not use permanent marked plots. I ran line transects, which are entirely acceptable for that kind of a study.

Q What kind of a study is that?

A A study to estimate the overall effects on that stand opposite the J. E. Corette plant as to annual growth.

Q You don't really consider that a control, do you?

A I would consider a control to be those plants that would be outside the area of immediate impact.

Q How far away is that?

A That would be in an area where the specific effluent from the plant would not be associated. It could be a matter of 50 miles; it could be a matter of a 100 or a 1,000 miles.

Q Where is your control plot?

A Control plots are not specific plots, but observations and measurements made in other areas where there are no effects of air pollution on the same species.

Q Where is your control plot?

A I have looked at areas that are unaffected by sources of air pollution from coal-fired power plants, such as in the areas around Fort Collins, Colorado. This would be in the Poudre Canyon area.

Q Is that a control plot for the ponderosa pine trees located around Billings -- in Colorado, in your mind, as a scientist?

A In my mind as a scientist it is a good estimation to be able to compare differences as to what effects might be observed

in ponderosa pine.

Q How many miles is Fort Collins, Colorado, away from the Corette plant?

A I don't have that number specifically in hand.

Q 500?

A I would say that I really don't have that number specifically in hand, and I would not like to venture a guess.

Q It's over 100 miles, isn't it?

A I think that's fairly safe to assume.

Q Did you establish any test sites or sampling stations to determine the ambient air concentrations of specific pollutants in and about the Corette plant at Billings in the vicinity of the trees which you looked at?

A I myself did not; no.

Q Did you familiarize yourself with any readings, if there are any?

A Yes, I did.

Q What was the average annual concentration of SO_2 in 1974 or 1975, you pick them?

A I do not recall.

Q Do you have that data?

A That data, I believe, is in the study for Yellowstone County Air Pollution Shudy.

Q Did you establish any ambient air sampling stations around Fort Collins?

A No, I did not.

Q Did you look at any limber pine around Billings?

A No, I don't believe so, as I recall.

Q Did you look at any lodgepole pine around Billings?
A Not as I recall.
Q Doctor, by chance in your visits to Montana did you ever examine the tree stands in the vicinity of the Anaconda Smelter in Anaconda, Montana?
A No, I have not.
Q Did you in your visits to Montana ever examine the tree stands in the vicinity of the ASARCO Smelter in East Helena?
A Yes, I have.
Q Did you establish any controlled tests to determine the effects of the emissions from the ASARCO plant upon conifer trees around the East Helena ASARCO plant?
A My studies around that plant were associated with, again, a similar type of studies that were done and conducted opposite the J. E. Corette plant, where measurements were made of annual growth and measurements were made as to leaf retention.
Q What was your sample size?
A Again the same, approximately 100.
Q 100 trees?
A Yes.
Q On a controlled radius from the source?
A I don't recall the specific distance from the source, but I do recall the fact that they were not specifically measured from the source.
Q Did you have a control area other than those close to the ASARCO plant?
A The area that I looked at was in the Helena National Forest.

Q How far is that from the East Helena plant?
A As I recall, it's approximately 50 miles.
Q Did you familiarize yourself with the EPA's publications on air pollution in the Helena Valley?
A Yes.
Q You're familiar with the conclusions of those studies?
A Yes, I am.
Q There was damage to conifers from SO_2, wasn't there, Doctor?
A It is reported in those studies that there was damage, yes.
Q You didn't see any, did you?
A I did.
Q Oh, what kind of damage?
A I saw typical type of SO_2 damage to leaves.
Q What is typical SO_2 damage to leaves?
A You want me to describe what the damage looks like?
Q I sure do.
A It is a light red, orange to yellow in color of the apex of the leaf, extending down to the basal portions of the leaf. There is a characteristic intergrading from this coloration to the nonaffected portion of the leaf.
Q Anything else?
A Those are the predominant aspects that I was looking for at that time.
Q Did you observe any premature needle cast?
A Would you repeat that again, please? I didn't hear.
Q Did you observe any premature needle cast from the trees around the East Helena plant?
A No, I did not.

Q How do you tell SO_2 damage from hydrogen fluoride, O_3 or NOx damage to a needle?

A Hydrogen fluoride damage to a needle has a clear line of demarcation as opposed to an intergrade. The needles are, when they turn chlorotic, they are yellowish in color. Ozone damage has a spotting appearance in any portion of the leaf where the spots of necrotic cells are rounded, yellowish to whitish in color, depending on the species that you're specifically associated with.

Q Necrotic means dead?

A That's right.

Q Have you ever subjected needles that have been exposed to hydrogen fluoride damage to chemical analysis?

A No, I have not.

Q How about ozone?

A No, I have not.

Q How about NOx?

A No.

Q And the same is true for histological work for all three of those?

A That is correct, as I stated before.

Q Well, I thought I was asking before just about SO_2. The question now is HF, O_3 and NOx and SO_2?

A Yes.

Q The same answer, you haven't done any histological studies?

A That's right.

Q As I understand it, Doctor, since 1974 when you were appointed the Senior Scientist with Westinghouse for interdisciplinary

assessment of impacts associated with major projects, you've been involved in 11 major projects?

A Those have been identified as those projects in which I have participated as a major participant; I played a major role in the impact evaluation.

Q You're not able to spend too much time at any one of those sites, are you?

A I spend enough time at those sites to conduct seasonal field studies at those sites, yes. One correction I would like to point out is my association with Westinghouse as a Senior Scientist was as of 1972, not as 1974 as you previously indicated.

Q I think that's clear in your statement. You were made the manager, though, in '74, right?

A That is correct.

Q What seasonal studies have you conducted around the Corette plant?

A As you are aware from my previous answers, my studies around the Corette plant are actual measurement-type of studies; empirical field studies have been initiated just since the time of my deposition and in that sense it would be impossible to do a complete year's seasonal study.

Q That's right. When did you commence your first observational field studies in the Billings area?

A That would be in the early part of June of 1975.

Q So we've only got seven months, then -- almost eight months -- that you've been looking at that, and certainly not during the winter?

A That is correct.
Q Nor the spring?
A It depends on what you consider June to be, spring, early summer.
Q Well, certainly before June most growth has commenced in the phenology of plants around the Corette plant, hasn't it?
A That is correct.
Q And you weren't watching the grass grow at that time of the year, were you?
A No.
Q Did you conduct any sampling to determine the soil moisture in the vicinity of the Corette plant since you started your studies?
A No, I have not.
Q What studies have you undertaken to determine relative humidity by calendar month in the vicinity of the Billings plant?
A The only data that I am using would be published data. I have not initiated any of my own field work to do that.
Q Doctor, what specific Montana species of botanical life have you conducted any study upon lasting in duration in the field for more than one year?
A Are you talking specifically about studies associated with the effects of air pollution?
Q Yes.
A None.
Q That includes a species growing in and around the Colstrip site, correct?

A For a period of more than one year, that is correct.
Q You're now 35?
A I'm sorry; I didn't understand you.
Q You're now 35 years old?
A That is correct.
Q And your first job upon graduation or completion of your studies to obtain your Ph.D. was with Westinghouse, right?
A Yes.
Q And prior to your association with Westinghouse you had no experience whatsoever, insofar as field work is concerned, related to reclamation effects, had you?
A That is correct.
Q Incidentally, you mentioned some reclamation work at the Braidwood site?
A Yes.
Q There were no scientific controls on the reclamation activities at the Braidwood site, were there, as of March 27, 1975?
A Well, I would like you to explain specifically what you mean by "scientific controls." My studies there were specifically to identify the different techniques used in reclamation, the species used, how they were used, what time of planting, the extent of their use, and also the length of time that they had to develop and how well they developed within that period of time.
Q I'll ask you, Doctor -- let's go back to your deposition, page 22, line 3. "Question: Were the reclamation activities at the Braidwood site structured and controlled?" "Answer: How do you mean, structured and controlled?" "Well, was

there controls in various reclamation plots or areas which told you time sequences, man-made?" "Answer: You mean scientific control?" "Question: Yes." "Answer: No." Did you give those answers to those questions?

A Would you repeat the last question again, please?

Q Did you give those answers to those questions when I asked them on March 27th, 1975, in your office in Pittsburgh?

A Yes, I did.

Q On line 24 you talk about "plant stack effluents on biota."

A Where are you reading from?

Q Page 1 of your statement.

A Yes.

Q What are plant stack effluents?

A I'm talking about specific effluents from coal-fired plant stacks.

Q What are they?

A They would include SO_2, NO_x, fluorides, particulate matter, trace elements.

Q Have you, Doctor, since joining Westinghouse or any time prior to that time, ever undertaken measurement activities with respect to effluents emanated from coal-fired generating facilites?

A I personally have not; however, I have used the information developed by Westinghouse and taken by Westinghouse in the meteorological section.

Q Have you ever run a study anywhere more than one year in duration where you have vegetation or botanical species growing around the coal-fired generating facility that are

marked, which have co-located with the test spots ambient air monitoring stations?

A I personally have not, no.

Q Let's look at page 2, now, of your statement. How do you define "bioecology"?

A Bioecology is the study of the ecology of biological organisms.

Q How do you distinguish that from autoecology?

A Autoecology is the study of the ecological aspects of a specific area as they relate to the ecological aspects of other areas. Auto means self -- it's a self derivative; therefore it is the ecology of a specific location.

Q Now, it says you've taught some classes in biology, ecology, morphology, phycology, taxonomy and advanced systematics. Taxonomy is merely the identification of plants, isn't it?

A Would you repeat that, please?

Q Isn't taxonomy the identification of plants?

A Yes, it is, if you're talking about plant taxonomy specifically.

Q I would assume so. You've had no training, have you, as a medical doctor?

A That is correct.

Q And you've had no training as a veterinarian?

A That is correct.

Q And you don't consider yourself expert, do you, Doctor, on the effects of pollutants upon man or animals?

A That is not correct.

Q You do consider yourself to be an expert upon the effects of pollutants upon human beings?

A I consider myself capable of interpreting the results of

those experts who have conducted studies in those areas.

Q Well, we can all read, Doctor, but have you ever conducted any studies yourself upon the effects of pollutants upon human beings?

A No, I have not.

Q Have you ever conducted any studies yourself upon the effects of pollutants upon animals?

A Other than literature studies, no.

Q I am interested, Doctor, in how you determined that there were only 130 pertinent publications applicable to the assessment of potential bioecological effects which may result from the Colstrip electrical generating facility.

A I did not determine that there were only 130 pertinent publications. All I simply said was that I had reviewed approximately 130 in addition to other supplementary information.

Q How many publications would you estimate have been made that examine some phase of the potential bioecological effects of the operation of a coal-fired generating facility?

A I would have no knowledge as to a specific number.

Q It would be in the thousands, though, wouldn't it?

A It would seem reasonable, yes.

Q When did you complete your portion of the environmental analysis prepared by Westinghouse for the applicants?

A I'm not sure that I recall the specific date. It would have to have been completed sometime before it went to publication.

Q Do you recall when it was published?

A 1973.

Q At the time you produced the portion of the environmental

analysis relating to terrestrial impacts you had not reviewed a large amount of work specifically oriented for the effects of pollutants upon species growing in the State of Montana, had you?

A Are you saying that I had not reviewed -- had not at that time?

Q Yes.

A That is incorrect. I had reviewed a substantial amount of work.

Q Doctor Edmonds, do you know a Helen J. Goetz?

A Yes, I do.

Q Do you know a William A. Beimborn?

A Would you repeat the name, please?

Q Beimborn -- B-E-I-M-B-O-R-N.

A Yes, Dr. Beimborn.

Q And they're both employees of Westinghouse Electric Corporation, right?

A Miss Goetz is no longer an employee; she has found other employment, as of last month, I believe.

Q As of April 23, 1975, you were requesting many references that you did not have in your library concerning acid rains, hydrogen fluoride, reclamation, from the University of Montana, were you not?

A That is not entirely correct. What I was doing at that particular time was gathering together all possible information, including replicate information, just to make sure that I had all of those important publications that I could possibly gather at that particular time.

Q Dr. Edmonds, I am handing you what has been marked as "DNR Exhibit 25," and I'm asking if you have ever seen a copy of this document?

A (PAUSE FOR WITNESS TO REVIEW) Yes, I have.

Q And was this letter transmitted to Dr. Gordon at your direction?

A Yes, it was.

Q And along with the letter is a list of several publications you did not have in your file, is that right?

A Not entirely. Along with that is a list of publications specifically cited in the DNR EIS.

Q You certainly didn't have the references in your library. You say so in the letter, don't you?

A I say that I don't have some of the references in the letter and many of the references cited there were cited for unpublished material.

Q Let's take for instance, Bohlen, "Case Study Contributions to the United Nations Conference on the Human Environment, Air Pollution --"

A I believe that I have that in my files.

Q But that was on the list of references attached to this letter requesting --

A That is nothing more than a list of references taken from a DNR EIS. Those are the specific references cited in that publication.

Q In any event, Doctor, Westinghouse did receive from Dr. Gordon each of those references requested, didn't they?

A No, we did not.

Q Doctor, I am handing you what has been marked "DNR Exhibit 26,

and I'll ask if that was received by Westinghouse in the regular course of business?

A (PAUSE FOR WITNESS TO REVIEW) Yes, it is; from this particular letter a notation should be made of the second and third page which also includes a list of that information which was not available to me at that time.

MR. SHERIDAN: I will offer DNR 25 and 26.

HEARINGS EXAMINER: You have two letters, 25 and 26?

MR. SHERIDAN: Yes.

HEARINGS EXAMINER: What's the date, Mr. Sheridan, on Exhibit 25?

MR. SHERIDAN: Exhibit 25 is April 23, 1975.

HEARINGS EXAMINER: And 26?

MR. SHERIDAN: May 2, 1975.

MR. PETERSON: I have no objections.

HEARINGS EXAMINER: DNR Exhibits No. 25 and No. 26 are admitted.

Q Now, Doctor, you state that you have been involved in the evaluation of the assessment of the potential effects associated with acid precipitation. You state that in your written statement on page 3, starting at line 3 through line 5. What have you done in the field to determine the presence or the effects of acid precipitation?

A In conjunction with the studies already described, I have looked on vegetation in those particular areas for any possible signs of effects of acid precipitation and have found none.

Q What are the signs of acid precipitation on vegetation by type?

A A bleached chlorotic spotting effect on the upper surface of the leaves.

Q Any others?

A That is the predominant surface characteristic.

Q Can you recall others?

A There are other secondary effects associated by some people with acid rain, such as premature leaf falling, long-short needle syndrome, secondary signs of that sort. These are not considered to be primary indicators in the sense that I am using the initial field work that I did.

Q And of course, none of the leaves or needles that you observed in the field were subjected to histological examination?

A I have already stated my answer to that on previous statements.

Q That was no.

A That is correct.

Q Did you undertake at any of your study areas the collection of rain water to measure pH?

A No, I did not.

Q What activities have you undertaken in the field, Doctor, which you have personally done to measure particulates?

A I have not conducted any studies for the measurement of particulates in the field. I am relying there, as with -- similar to pH measurements in the field, upon those studies that have already been conducted by other individuals.

Q Have you ever, Doctor, in the laboratory, conducted spray experiments for the effects of acid precipitation upon ponderosa pine?

A No, I have not.

Q Any other species?
A No.
Q Have you ever conducted in the laboratory fumigation chamber experiments to determine or observe the effects of SO_2 or hydrogen fluoride or ozone or NO_x upon conifer species?
A As with other studies that you have indicated before, my knowledge in those areas has been obtained through those studies that have been conducted by other individuals.
Q You then have not done it yourself?
A I have not personally conducted laboratory examinations, no.
Q In fact, Doctor, there have been no fumigation experiments or studies conducted by you or anyone on your behalf upon conifer species of the type growing in the vicinity of Colstrip since your involvement on behalf of Westinghouse; have there?
A Studies have been conducted, naturally, on the species. I personally have not conducted them.
Q Has anyone conducted studies of that nature on your behalf? Or at your direction?
A No.
Q Have you collected any vegetative samples in and around the Corette plant at Billings to determine whether or not damage has been incurred as a result of exposure to emissions from the Billings plant?
A I have collected many samples, yes.
Q Have you collected those samples for chemical analysis?
A No, I have not.
Q Doctor, as a scientist do you think it's more scientific and more conducive to complete investigation to rely upon your

eyeball on one hand, or to rely upon observations, chemical analysis, and microscopic study on the other?

A I believe as a scientist that all available information of every type should be obtained and assimilated and utilized in complete assessments of the particular criterion that you are trying to measure or study.

Q In other words, you would rather use histological work, microscopic slides, chemical analysis, if that were available to you?

A I would like to have them available to me so that I can interpret the relevance and importance of those studies, as well as any other studies available.

Q You haven't done that at Billings, have you?

A At Billings, as well as in other areas that I have been looking at, I have tried to assimilate all available information.

Q Have you ever looked at the histological studies of the ponderosa pine needles collected around the Billings plant?

A As I recall, there are no specific studies done, histological studies done right around that particular plant, but I may be mistaken. I know there were studies done in the general area.

Q Doctor, what scientist in the State of Montana has probably done more investigation of the effects of pollutants upon species growing in the State of Montana?

A In what respect? Would you rephrase your question?

Q Collection of samples, histological studies, and vegetative analysis?

A Were you speaking specifically of histological studies?

Q Histological studies, vegetative analyses, or the collecting of samples -- all three?
A I don't think that I could say what particular individual has done more than any other. I know that there have been a great many studies done. Studies have been done by individuals within the State of Montana, as well as at other universities in other states, on species that are specific to Montana.
Q Do you know any scientist other than Dr. Clancy Gordon who's done more?
A Pertaining to what particular subject?
Q The effects of acid rain upon conifer species in the State of Montana.
A There has been a great deal of work done by other investigators. I would not like to say that one has done more than another. I think a substantial portion of work has been done by a number of different people.
Q You don't know, is that your answer?
A My answer is not quite that. For example, Dr. Wood & Pennypacker have done a considerable amount of work; now, whether they've done more than Dr. Gordon has, I don't think that I should be able to say at this point.
Q In the State of Montana?
A On the species that are specific to the State of Montana.
Q But not in the State of Montana?
A I don't know.
Q Have you familiarized your self with the work performed by Dr. Abraham Hindowi?

A To some degree, yes.
Q Do you know where he's located?
A I believe at Corvallis, Oregon.
Q At what facility?
A I believe his association there is with the EPA.
Q Did you ever talk to Dr. Hindowi about his studies on the effects of acid rain upon conifer species?
A No, I have not.
Q Have you ever talked to Dr. Gordon about that?
A Yes, I have.
Q When?
A On a number of occasions. I would say the first time would be when I was just beginning my studies on the Colstrip report. Dr. Gordon called me for information about what kind of studies I was doing, and what particular things I was looking at and considering relative to the air pollution aspects. At that time I told Dr. Gordon specifically what I had intended to do and how I was going to go about doing it, and at that time I asked him for his help in providing me with any pertinent information which he thought might be useful to that particular study.
Q Did you ever go to see Dr. Gordon in Missoula and visit his laboratory?
A No, I have not.
Q Have you ever seen the thousands of pictures that he has?
A I have seen some of Dr. Gordon's pictures, yes.
Q By the way, Doctor, have you taken any infrared photographs of the area around Billings?

A I personally have not, no.
Q You're familiar, are you not, with the method of infrared photography for determining vegetative health?
A Yes, I am.
Q What do you seek to do?
A Do you want me to describe what you look for?
Q Sure; right.
A Infrared photography is a methodology for getting a growth assessment of vegetation which may be affected by a number of different sources, including air pollution damage, insect damage, other types of blight, various stress of organisms, and this is evaluated through aerial infrared photography by comparing heat differentials for specific kinds of vegetation.
Q It would sort of help you to determine if there's any pattern of damage around a coal-fired generating facility that may be related to effluents from that plant if you had the advantage of infrared photography, wouldn't it?
A Infrared photograph would be one tool of many that could be utilized to get an indication.
Q You've never used that tool, have you?
A No, I have not personally ordered infrared photographies to be taken around that particular plant.
Q Let's go to your section on acid precipitation, starting at page 3.

HEARINGS EXAMINER: Let's take a little recess, please.

(RECESS AT 10:00 A.M.)

Following a brief recess, the hearing reconvened at 10:30 A.M. on January 29, 1976.

HEARINGS EXAMINER: Very well, you can proceed with your cross-examination.

CONTINUATION OF EXAMINATION OF DR. PETER R. EDMONDS

Cross, by Department of Natural Resources and Conservation

By Mr. Sheridan (continuing):

Q Dr. Edmonds, turning to page 3, the first sentence there, commencing line 8, you say, "For acid precipitation to be clearly distinguished from the acidic component of normal precipitation, it may be defined as rain or snow having a very strongly acid pH." Define in absolute terms what you mean, "very strongly acid pH".

A As I have described in the statement, I am considering acid rain to be acid precipitation that would have a pH value of somewhere below pH 5.

Q What's the pH of vinegar?

A Vinegar is a weak acid, acidic acid, it has a PK constant of approximately 6; pH, I am not sure of the exact pH, or normal pH, of vinegar at this time. It is a weak acid.

Q A weak acid?

A Yes.

Q Do you consider sulfuric acid a weak acid?

A I consider sulfuric acid to be a strong acid. It has a PK constant of approximately 2 -- a very low PK.

Q Do you consider hydrochloric acid to be a weak acid?

A I consider hydrochloric acid to be an extremely strong acid.

Q What's the PK?
A I don't recall right offhand.
Q Is 3.5 about it?
A I would think not. I am speaking now of PK.
Q Now you make the comment, "It has been suggested by some that acid rain may be an environmental concern at Colstrip, Montana." Who do you mean, "some"?
A This is a suggestion that has been brought out in the DNR EIS.
Q That's about as specific as you are, right?
A Well, it has been specifically brought out in the DNR EIS that acid rain may certainly be an environmental concern.
Q What have you examined concerning the acid precipitation question in Montana?
A I believe that my testimony so speaks what I have examined and how I have examined it.
Q Have you ever made or collected rain water to measure pH around any facility in the State of Montana emitting SO_2?
A I have relied upon the information developed by other sources.
Q Dr. Frohliger did not measure rain water in the State of Montana, did he?
A Dr. who?
Q Frohliger. F-R-O-H-L-I-G-E-R.
A I see. You have a different pronunciation than I do. All right, as far as I am aware, no, he did not.
Q Have you in anyway in the United States undertaken to collect rain water samples around a coal-fired generating facility with the specific intent to determine the pH of that rain

water?

A I personally have not.

Q Have you ever seen the effects of acid precipitation on vegetation growing in the wild?

A I have seen what could be interpreted as acid precipitation effects, but I have not been able to specifically say that they were. They looked more to me like those effects associated with ozone damage.

Q Have you been to Mt. Storm?

A Have I been to Mt. Storm?

Q Right.

A No, I haven't.

Q There's been quite a bit of controversy there concerning the effects of acid rain upon Christmas trees, hasn't there?

A I would say that the subject has been studied, yes.

Q It has also been in litigation, hasn't it?

A Yes, it has.

Q And damage awards have been given, haven't they?

A I didn't hear that. Would you repeat your question?

Q Damage awards have been given, haven't they?

A I suppose so. I have no direct knowledge of that.

Q You never talked to the Virginia Electric Power Company people concerning the effects of their 4,000 megawatt generating facility at Mt. Storm, West Virginia?

A No, I have not.

Q With that much controversy, wouldn't it be a nice thing to know for you as a scientist whether or not studies have been conducted and the depth of those studies concerning the acid

rain question at Mt. Storm?

A I think it would be very desirable.

Q Have you ever talked to any of the scientists working on it?

A Yes, I have.

Q Did those scientists tell you that over a million and a half in damages have been paid by settlement?

A I have heard stories to that effect. As I indicated before, I have not seen any definitive information relating to that, so I cannot specifically say that I am aware of it.

Q Since you haven't really seen it nor done any of the studies I assume you don't have the 95% confidence factor?

A I am fully aware of those studies that have been conducted there by several individuals who have conducted experiments that would relate to those kinds of factors.

Q Dr. Wood?

A That is correct.

Q Have you ever been around the TVA plants in Tennessee, specifically the Cumberland plant, to investigate the acid rain question there?

A I personally have not.

Q You have not, I take it, familiarized yourself with the acid rain problems in studies conducted by Batelle?

A To some degree I have, yes.

Q Incidentally, Doctor, what is the PK of HF?

A I don't recall right offhand.

Q It's about 3.4, isn't it?

A It may be.

Q What does PK mean?

A PK is the measurement of the dissociation constants of an acid.
Q What does that tell a scientist?
A It tells the scientist the strength of the hydrogen ion concentration dissociation.
Q It tells you to keep your bare hands out of it, doesn't it?
A That depends on what the PK is.
Q Well, take 3.4.
A If it were 3.4 I would hesitate to put my bare hands into it, yes.
Q What would it do to it?
A At 3.4?
Q Right.
A I would feel extremely warm.
Q Turning to page 4 of your statement, you've got a table there for the acid pH values put out apparently by the Department of Agriculture. Are those pH values for acid rains or for dirt?
A Those pH values are range values that indicate just various descriptive levels of pH in solution.
Q That is in solution?
A That's correct.
Q Where did you get that table from?
A That was, as was so stated, taken from the U.S. Department of Agriculture Soil Conservation Service.
Q Do you have a more specific reference?
A It is from the Soil Survey Manual.
Q How do scientists in the State of Montana deal with pH? Have

you talked to anybody from Montana in the Soil Conservation Service?

A On that particular subject, no I have not. Since this is a specific reference from their Handbook No. 18 I would assume that they would at least utilize that particular manual. It is a standard manual accepted throughout the United States.

Q Is that for acid rain or for dirt?

A Just for description of pH and how they, as I have indicated, described generally pH values, pH ranges.

Q It is your understanding that that range is for solutions as opposed to soils?

A Well, they use that particular range for measurement of pH in soil solutions.

Q I am interested in your discussion of the use of methyl orange, commencing about line 15 on page 4. You make the statement discussing precipitation pH, prior to 1940 that by inference precipitation pH prior to 1940 was assumed to be near 5.7. Upon what data do you rely for that statement, Doctor?

A Whereabouts are you referring to again?

Q Line 19, page 4.

A I'd like an opportunity to read that, if I may.

Q Surely.

A What is your question again, please?

Q What citation or authority do you have for that statement, "By inference, precipitation pH prior to 1940 was assumed to be near 5.7"?

A That comes from a publication from Likens and Bormann on acid rain precipitation.

Q Now you say, "It had formerly been incorrectly assumed..." Who incorrectly assumed that the pH values lower than 5.7 carbonic acid would dissociate to water and gaseous carbon dioxide?

A This is also covered in the publication by Likens and Bormann, to the best of my knowledge, as I recall, and also from a Dr. Krupa, who is Assistant Professor of Plant Pathology at the University of Minnesota.

Q Now, if it were incorrectly assumed that pH values lower than 5.7 carbonic acid would dissociate to water and gaseous carbon dioxide and that lower pH values resulted from nearly pure strong acid solutions, would not the inverse be true, that carbonic acid is responsible for pH's of 5.7?

A That is possible.

Q Isn't the weight of authority in the publications to that?

A Would you repeat that, please?

Q Isn't the weight of authority in written publications in coincidence with that statement?

A The authority indicates that that could possibly be the case.

Q Much more the publications indicate that it could be that way rather than the former that you set forth?

A The publications so state that it really isn't clear that it would be that way or the other.

Q Well, it's a minority view that you assert as far as incorrectly assuming that the pH values lower than 5.7 carbonic acid would dissociate to water, isn't it?

A Yes.

Q Now, Doctor, you state that in the early 1970's carbonic acid concentrations equaling or exceeding strong acid concentrations in rain water of pH 4.45 were found. By whom?

A This was found again by Dr. Krupa of the University of Minnesota.

Q In how many percent of atmospheres of CO_2 was that?

A I don't recall right offhand.

Q What was the article?

A This was in unpublished information, a personal communication with Dr. Krupa.

Q It has never been published in the scientific community?

A As far as I'm aware, it has not.

Q When was this done?

A That was done -- the actual communication itself?

Q Well, it hasn't been published; he's got to talk.

A To the best of my knowledge, that was back in December of 1974.

Q How did he collect the rain water?

A I don't recall from that time the absolute details of the conversation. I could look up my notes relative to that.

Q Did he use dry ice like Frohliger?

A I don't specifically recall.

Q Now, the statement you make following the report of pH 4.45 and strong acid concentrations of rain water is that, "This evidence indicates that carbonic acid can occur in acid precipitation and can contribute substantially to the strongly acid reaction." Now, the only source that you have

for that statement is by this personal communication, isn't it, Doctor?

A I think that the fact that carbonic acid can occur in acid precipitation is a generally accepted and well-known fact at the present time.

Q Does, in your opinion, this contribute to the strong acid reaction in carbonic acid?

A I think based on this evidence that there is a strong indication that it can, yes.

Q Which evidence is that, Doctor?

A Evidence from Likens and Bormann; evidence from Dr. Krupa.

Q Does it contribute to the pH with strong acids?

A Does it contribute to the pH?

Q Yes.

A I believe it does.

Q Has anyone ever said that CO_2 cannot exist in solution?

A Would you rephrase your question, please? I'm not sure I understand what you're asking.

Q Right. Has anyone ever stated that CO_2 cannot exist in solution?

A That depends on the specific pressure associated -- atmospheric pressure associated with the solution and with the gas.

Q You will concede, however, Dr. Edmonds, that the statement you make starting at line 20 and continuing through line 26 is definitely by the great weight of authority a minority view?

A Are you talking about on page 4?

Q Yes.

A Now, would you repeat what it is that I would concede to?
Q Okay; "it had formerly been incorrectly assumed that pH values lower than 5.7 carbonic acid would dissociate to water and gaseous carbon dioxide and that lower pH values resulted from nearly pure strong acid solutions. However, in the early 1970's, carbonic acid concentrations equaling or exceeding strong acid concentrations in rain water of pH 4.45 were found." Now, that's a minority position, isn't it, Doctor?
A Yes, that is a position that is taken by Dr. Krupa, based on his experiments.
Q Which he's never published in the scientific community?
A Not that I'm aware of. At the time that I was talking to Dr. Krupa, that was a personal communication. I'm not aware of a specific publication by him on that subject.
Q It has not been presented at any symposium nor has it been subject to the scrutiny of the scientific community, to your knowledge, has it?
A That is correct.
Q So it follows, then, doesn't it, Doctor, that on page 5, commencing at line 4, that a very tiny minority of the scientific community question whether the solubility of carbon dioxide in precipitation has ever been governed by the pH of rainfall; -- Excuse me, has ever governed the pH of rainfall?
A I would not agree with that statement whatsoever. I would say that I have no particular way of determining at this point in time whether a small minority of the scientific community

agrees or disagrees with that particular statement, but in answer to that particular question, and in specific reference to that line that you are referring to, I would like to quote to you a publication from Dr. Frohliger.

Q Before you do that, let's talk about Dr. Frohliger. First of all, his view is a minority view, isn't it?

A That I don't know. All I know is that that is his particular view.

Q His was the first publication ever discussing this, wasn't it, Doctor?

A It is one of the first ones that I'm aware of, yes.

Q What's the date of that publication?

A The date of that publication that I have is August 8, 1975, in the Journal Science. Now, I'd like in answer to that previous question --

Q Just a minute, Doctor, just a minute. Can you say, as a scientist, that the majority of the people or the scientists involved in this research do not question this statement that you made?

A I cannot say whether the majority agree or disagree or whether the minority agree or disagree. I have not taken a survey of the scientists. However, I would appreciate the opportunity to read to you this particular reference, that I may complete my previous answer. May I do that at this time?

Q What page?

A This is page 455, August 8th, 1975, from Science, Vol. 189, abstract of a paper entitled "Precipitation, It's Acid Nature:"

"A comparison of free hydrogen ion concentration and a total hydrogen ion concentration of rain samples show that rain is a weak acid. The weak acid nature of rain casts doubt on the concepts that the acidity of rain is increasing and that these increases are due to strong acids, such as sulfuric acid." On page 457 of that text, he indicates in the conclusions that the precipitation is best characterized as a weak acid, rather than a strong acid such as sulfuric acid, H_2SO_4, and that the pH of rainfall was -- he doubts whether the pH of rainfall was ever controlled by the solubility of carbon dioxide, CO_2, in the precipitation.

Q Well, Doctor, how did the CO_2 get in there?

A CO_2 is dissolved in water, forming carbonic acid.

Q How did Dr. Frohliger collect his rain water? I'll shorten it up. Didn't he use dry ice?

A Yes, he did.

Q How many other scientists have used that method for the measurement of pH in rain water?

A I have no way of estimating how many other scientists have used that particular method.

Q What is dry ice?

A I am not absolutely sure of its chemical constituents.

Q Isn't it frozen CO_2?

A Yes, but I'm not sure whether there are any other chemical constituents in it.

Q Doctor, what is the typical range of CO_2 concentrations one can expect to find on the average in open areas, such as in forests or on the plains?

A I don't recall those numbers right offhand.

Q I've just handed you, Doctor, a source document entitled "Chemical Rubber Company's Handbook of Chemistry and Physics;" do you recognize that as being authoritative?

A Yes, I do.

Q Turn to page F-151.

A Yes.

Q Now, tell me the answer to the question.

A Would you repeat your question?

Q What's the typical range of CO_2 concentrations one can expect to find on the average in open areas, such as in forests or on the plains?

A I can't from this page pick out specifically where you would expect me to find that answer.

Q Is it .033?

A Plus or minus .01.

Q That's close enough.

A That is the normal component of CO_2 in atmospheric air.

Q That's about 100 to 500 ppm, isn't it?

A That's correct.

Q In Frohliger's paper -- you've got it right there, don't you?

A Yes, I do.

Q An average pH of 3.9 was found, wasn't it?

A Where is that specifically stated in the paper? Again, in this, if you're expecting me to look this up and pinpoint the exact area I'd appreciate your letting me know where it would be found.

Q Sure. First of all, Doctor, would you expect to find the

typical range of CO_2 concentrations of 100-500 ppm, or .03%, in and around Colstrip?

A I would expect somewhere within that range, yes.

Q What's the average pH in Frohliger's science paper you have there?

A The average or median pH is, as so stated, 4.68.

Q Not the median, the average.

A Pardon me?

Q Not the median, the average.

A He states it as average, yes; average pH.

Q Now, Frohliger, as I understand it, claims that average to be chiefly a result of dissolved CO_2, right?

A That is correct.

Q Do you agree?

A I agree with his conclusion, but I cast serious doubt as to whether or not a acid rain, a strong acid rain, would be controlled by H_2SO_4.

Q Why?

A Because of the obtaining of a strong acid component with the use of CO_2, a weak acid.

Q If this pH was caused by dissolved CO_2, what percent CO_2 in the surrounding area would be necessary?

A I wouldn't know that information right off the top of my head.

Q It would be 80 or 90, wouldn't it?

A If you say so.

Q Well, do you seriously doubt it?

A I would not like to comment one way or the other until I've had a chance to do my own analysis of that. If you indicate

that that's what it is, then I'll take your word for it.

Q Okay. Doctor, let's assume that the percent CO_2 in the air is .03; what would we expect to see for the pH of a solution of water in equilibrium with it?

A Would you repeat the last part of that? What would I expect to see?

Q What would you expect to see for the pH of a solution of water in equilibrium with it?

A I would not expect to find any change in the pH.

Q Assuming no other acids are present what would you expect?

A And it is at equilibrium?

Q Right.

A I would not expect to find any change.

Q Well, would it be pH 7?

A I don't know what the specific pH of that would be.

Q You really haven't done too much intensive study of Frohliger's paper, have you?

A I've read through the paper definitively some time ago. If you would like me to comment specifically on that paper, I could review it again. I have it right in front of me.

Q Well, I can see that you're unable to answer some of the questions which are easily elicited from Frohliger's work. Why don't you review that right now?

A (PAUSE FOR WITNESS TO COMPLY) All right.

Q Dr. Edmonds, I have handed you what has been marked as "DNR Exhibit 27," and I will represent to you that this is a graph which shows the percent of CO_2 in the air required to give a given amount of pH, and you can take a look at that graph

and check the formulas, if you so desire, and refer to CRC's handbook in front of you.

A (PAUSE TO COMPLY) Okay.

Q Does that seem reasonable to you?

A Yes.

Q What percent CO_2 in the air, looking at DNR Exhibit 27, would be required to reach Frohliger's mean or average pH?

A It would be approximately 1%.

Q How, Dr. Edmonds, would you get a 1% CO_2 in the atmosphere?

A Specifically, I don't know. It would depend on the individual situation and what would cause those particular atmospheric concentrations.

Q Well, don't you have to increase the pressure?

A That's one way.

Q If you don't increase the pressure, don't you have to increase the concentration?

A Increasing the concentration is another method.

Q How do you increase the concentration?

A Of CO_2?

Q Right.

A Are you speaking of atmospheric CO_2?

Q Yes.

A One way to do that would be to increase the pressure.

Q Another way would be to increase the concentration, right?

A Yes.

Q And one source of that could be dry ice?

A Are you saying that dry ice would increase the pressure?

Q It would increase the concentration, wouldn't it?

A I would imagine that there might be some possibility of that occurring, but it would depend on the overall temperature and experimental regime.

Q Okay, you have Frohliger's collection apparatus information there?

A Yes, I do.

Q Can you confine in a closed area dry ice?

A Can you confine it, did you say?

Q Yes.

A Not for very long.

Q What happens?

A Well, because of the increase in pressure the atmosphere about that would expand.

Q Would you read Frohliger's collection apparatus there?

A I can't seem to find the exact place where he describes this.

Q Well, outside of the fact that dry ice is used in Frohliger's collection apparatus, where, as a reasonable man, could that CO_2 come from in the rain water?

A I would not have any way of speculating on that without knowing more details of his experimental procedure.

Q What's the lowest pH in Frohliger's paper?

A 4.12.

Q What's the percent CO_2 to get that figure?

A I don't know.

Q From the graph I gave you, which is DNR Exhibit 27.

A It would be approximately 55%.

Q Pardon?

A It would be approximately 55%.

Q Doesn't it seem to you that the readings obtained by Frohliger would be the result of a poor collection procedure?

A I cannot say that whatsoever without being completely familiar with what collection procedure he has used, in detail. That particular procedure is not described in that much detail in this particular paper.

Q Where did the CO_2 come from?

A I don't know, and I would not like to speculate.

Q Do you have a yellow paper by Frohliger in front of you?

A Yes, I do.

Q Look in there and see if you can find a description of the collection device. There's a picture of it.

A (WITNESS COMPLIES) I can't seem to find it right offhand. If you know where it is, I'd appreciate your telling me.

(MR. SHERIDAN COMPLIES) That is on page 11?

Q Yes. Do you think that device that Frohliger used to collect the rain water could confine CO_2 -- or confine dry ice, I mean?

A I would not be able to say from the description that he has provided.

Q Would you expect it to?

A I would not be able to say that, because that completely depends upon the amount of sealant that he had in that area, whether there was any possibility for escape of pressure.

Q Where else could the CO_2 in the air come from to get that low pH if it didn't come from the dry ice through seepage?

A Again, I would not like to speculate on that particular answer unless I knew more about his particular collection

procedures.

Q If it didn't come from the dry ice how did the CO_2 get in the air?

A I repeat my previous response.

Q Doctor, as I understand it now, you're relying on the opinion you are giving me now on a minority view.

A All I said was that it is questioned. All I said is that it cast doubt on the fact, and I do believe still that this particular paper of his does indeed do just that. It raises questions as to whether the previous information supplied is actually valid, or whether there might be some other parameters that may be measured.

Q It does raise questions, then, in your opinion, but you cannot state, can you, Doctor, with a 95% confidence factor, that Frohliger is right?

A I can question, as I have indicated in my testimony, whether the solubility of carbon dioxide in precipitation ever has been governed by the pH in that rainfall.

Q Based upon these experiments, by Frohliger?

A Based upon Frohliger and based upon the previous references that I've referred to.

Q Well, the only other reference you gave me was a personal communication.

A That is correct.

Q And that hasn't been published?

A That is correct.

Q Doesn't that seem to be rather tenuous to you, to rely upon as a scientist, knowing the peer review given specific theories

by scientists in the field?

A I have no reason to doubt the information that I have received.

Q And that's based upon the possible situation --

A It's based upon the presumptions that I have made in my testimony.

Q Incidentally, Doctor, the conditions that Frohliger has insofar as CO_2 is concerned, if you look at DNR Exhibit 27, would they or would they not preclude human breathing in that atmosphere?

A I didn't hear the middle part of that. Would they or would they not what?

Q Preclude human breathing in that atmosphere?

A I have no idea.

Q 90% CO_2?

A I have no idea, no way to speculate on that, on your part or mine.

Q Down at the bottom of page 5, Doctor, is that 3.3 milligrams per liter or micrograms per liter, line 27?

A That is milligrams per liter.

Q First of all, Doctor, on page 6, starting at line 9, you give us some discussion about the change-over in the air in England and central Europe, and then you go on to say, "The conversion to oil resulted in a decreased ash content and reduced quantities of particulates reaching the atmosphere with a concomitant increased acid content in the atmosphere." What is the relationship of NO_x to oil and natural gas facilities vs. coal-fired burning facilities?

A I'm not sure I understand your question. What is the

relationship of NO_x to what?

Q The relationship of NO_x in natural gas and oil utilities and plants vs. that of coal-burning power plants?

A NO_x would be a normal constituent that would be encountered on the burning of these fuels.

Q From oil burning power plants you generally get about 60% NO_x to SO_2, don't you?

A I don't recall those particular figures right offhand. I'll accept what you say as being reasonable.

Q It does strike you as being reasonable?

A Yes.

Q It should also strike you, doesn't it, that with a coal-fired power plant you get about 25 to 40 percent NO_x to SO_2?

A Within that area, yes.

Q Assuming those facts, Doctor, conversion of coal to natural gas and oil would increase NO_x markedly, wouldn't it?

A That factor alone would, yes. I don't see what that has to do specifically, though, with the statement that you're referring to. What I'm talking about here is the total acid content in relationship to sulfur dioxide.

Q Going on to the direct correlation between the acidity in air or in precipitation in the industrial release of sulfur. What is a direct correlation in the context you use it here? 95% confidence?

A What confidence?

Q 95% confidence.

A I have no idea what the specific confidence level was for the studies that he's done, because I am not privy to the specific

information that he had in all of his data. I assume that if he were -- I'm speaking of Ode'n, who has published this information, as you are aware -- that he would have obtained this information, yes, with that level of confidence.

Q Now, Doctor, I want you to give me the citation for the statement that a very strong correlation -- and I assume at 95% confidence -- has been found between the agricultural application of nitrogenous commercial fertilizers and the nitrogen content of precipitation.

A That would be from Ode'n's publication, "Acidification of Air and Precipitation and Its Consequences."

Q Where, in Europe or the United States?

A In the natural environment.

Q In Europe or the United States?

A That was in Europe.

Q Now, you say, "The application of nitrogenous commercial fertilizers has resulted in the release of about twenty percent to the atmosphere." Releasing 20% of what to the atmosphere?

A Of nitrogen.

Q Now, the nitrogen component of commercial fertilizer is alkaline, is it not?

A That is correct.

Q How do you get chemically from basic nitrogen to oxidized nitrogen in the atmosphere?

A From the degradation of the sulfur components of the fertilizer and the formulation of HF.

Q Are you familiar with the nitrogen cycle?

A Yes, I am.

Q Would you go up to the board there and draw it, and mark it DNR Exhibit 28?

HEARINGS EXAMINER: I missed 27, I guess.

MR. SHERIDAN: I have it.

(PAUSE FOR WITNESS TO COMPLY)

A In general I have indicated this.

Q That's the nitrogen cycle, right?

A As a general representation of it, yes.

Q Now, we're starting basically with NH_2, aren't we?

A NH_2.

Q How do we get from NH_2, which is what? What's NH_2?

A Nitrates.

Q Nitrates -- A-T-E-S?

A Yes.

Q How do we get from NH_2 to NH_3?

A By the oxidation of nitrates, formulation of ammonia.

Q Now explain for me how you oxidize ammonium, NH_3, to NO_2.

A This is done in large part by anaerobic bacteria, in the soil.

Q How about in the air?

A In the air it is formed by lightning as I have indicated.

Q By lightning?

A That's one method.

Q Any other methods?

A By photo-oxidation.

Q Doctor, in your statements relating to the use of nitrogenous commercial fertilizers did you make an investigation to determine by regions in the United States the comparison of fertilizer applications by region?

A I noted the fact in the statement that there was a correlation between the high use of fertilizer in the northeastern portion of the United States, in heavily agricultural areas.

Q Did you review the text which I've handed you now in doing so?

A No, I have not.

Q Well, to shorten this up, I think I'll tell you some things about what's in there, and if you want to question them, you can look. Otherwise, I will ask you to assume them to be true.

MR. PETERSON: I'll object to this line of questioning as not the best evidence.

MR. SHERIDAN: We can wait and I can have him go through it. I'm going to ask him the questions.

MR. PETERSON: How long is it? It's probably another one of those 900 --

HEARINGS EXAMINER: I'll overrule it. He can ask the questions.

Q Doctor, the document which I've handed you shows the total nitrogen fertilizer applications in the United States, by region, for the year 1973. Who published that?

A Did you ask me a question -- who published that?

Q Right.

A Well, this particular document that you have handed me is published by Norman L. Hargett, The National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Alabama.

Q Would it surprise you to learn, Doctor, that the most nitrogen fertilizer applied by region in the United States in 1973 was in the west north central of the United States, and I'll give

you the states that represents --

MR. PETERSON: To which I'll object on the grounds that it assumes facts not in evidence.

HEARINGS EXAMINER: Overruled.

Q Those states being Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska and Kansas.

A That would not surprise me in the least.

Q And would it surprise you to learn that the nitrogen fertilizer applications at New England were the lowest in the United States, those states being Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut?

A No, that would not surprise me, either.

HEARINGS EXAMINER: For clarification purposes, is that information contained in the document you are showing?

MR. SHERIDAN: I'll represent that it is.

WITNESS: I have not seen it, but I'm not surprised.

MR. SHERIDAN: I'm asking him to assume this. I've gone through it and added it up, so --

Q Where is all the acid rain in the United States?

A In the eastern United States in the same areas that are associated with high fertilizer use.

Q The nitrogenous fertilizer applications in New England were --

A New England is not the only eastern part of the United States.

Q All right, pick another state. I've got them for every one.

A Pennsylvania.

Q Pennsylvania is in the middle Atlantic. It's less than 1/10 of the west north central United States, and the figure is

284,180 tons.

A According to the classification for its location in this particular report that I assume you are quoting from; that's where they have placed it. I consider the eastern part of the United States to be that area from Ohio east.

Q Do you know what the west north central United States total was?

A Of course not. I have not seen this document.

Q Okay, I'll represent to you it's 2,646,547 tons, more than 10 times the middle Atlantic.

A Do you have a summation of the total for the total fertilizer that would be utilized for those states that I have indicated that I have used in my report?

Q I certainly do. It's right in there.

A In this document?

Q And it's done by region.

A It's done by regions, and those regions, as I have indicated, are different from the regions I have described in my testimony.

Q You say the Great Plains, don't you?

A I said from Ohio east.

Q What states do you consider the Great Plains?

A I would consider Minnesota, Kansas, Oklahoma -- in that area.

Q Do the nitrates contribute to the acidity of rain, in your opinion?

A In my opinion, there is a good correlation from the literature I have surveyed between the amount of fertilizer used, the nitrates associated in the air with the use of those fertilizers, and the formation of acid rain.

Q Does that correlation to you as a scientist say cause and effect?
A To me as a scientist it says that there is a strong indication, as I have stated.
Q You certainly don't attach a 95% confidence factor to it, do you?
A Unless I were to go out and do the specific tests, as not to my knowledge have been done, then I could not do that with that, but it would be a strong indication, as I have so stated in my testimony.
Q Can you say that nitrates can hydrolyze to nitric acid?
A Could I say that?
Q Well, would you as a scientist say it, Doctor?
A No.
Q NO_3, right? Isn't ammonia a base?
A As I have indicated, this is from a breakdown of the sulfate compounds in the soil associated with nitrogen, the formulation of HS.
Q Doctor, looking at line 27 on page 7, whose study are you referring to that says "increased nitrogen content of precipitation correlated well with the increase in nitrogen-containing commercial fertilizers"?
A I am referring to Odeh's study again, for acid precipitation in the natural environment.
Q And that's in Europe, isn't it?
A Odeh has done his studies in Europe, yes, that is correct.
Q And he has not done them in the United States?
A That is right.

Q Yes, so it's only an assumption on your part that the same thing happens here?

A Well, in reading through that testimony that is precisely what I have said. I have said, "Although the source of the increased nitrate levels has not been specifically identified, a similar situation as described (by Ode'n) for northwestern Europe where the increased nitrogen content of precipitation does correlate well with the increase in nitrogen-containing commercial fertilizers."

Q Of course, Doctor, that assumption flies in the face of logic, assuming that nitrogen-containing fertilizers being used in the New England states are not 1/10 as great as the nitrogen-containing fertilizers being used in the Great Plains region, doesn't it?

A The increase in fertilizer use, as well as with the increase in non-coal fuel, is reasonable to assume that there would be a correlation.

Q Now, Doctor, on page 8 -- on page 9 --

A I'm missing page 9 in my testimony. (PAGE 9 GIVEN TO WITNESS) Thank you. Yes.

Q Looking at line 13, page 9, you say -- you are explaining three points. One point you make is, "The recent increase in precipitation acidity in northwestern Europe and New England was correlated with and possibly caused by the increased use of nitrogen-containing fertilizers even though sulfate may have been a contributing factor." Doesn't that disagree, Doctor, with what you said on page 7, line 28, and page 8, line 1?

A I don't understand why you would think that these two statements disagree.

Q Well, Doctor, didn't you just say that nitrate could not hydrolyze to nitric acid?

A That is correct.

Q How, then, is it responsible for the acidity?

A As I indicated that is because of the sulfur associated compounds with the fertilizer. Nitrogen is just an indication of what degree or what amount of fertilizer would be in the atmosphere.

Q What are nitrogenous fertilizers?

A What are they?

Q Yes. What do they contain? Don't they contain N as NH_3 as a base?

A Yes.

Q Or NO_3 minus salts?

A Some of them do, yes.

Q And don't these salts -- these salts do not hydrolyze NO_3- $+H_2O + NO_3 + OH$-?

A That is correct.

Q Then they can't cause outgoing solutions to become acidic, can they?

A Not in those forms. As I've indicated there's a sulfur associated with these compounds, as HS.

Q What form is the sulfur?

A A breakdown through normal anaerobic components in the soil.

Q We're talking about the air, now, though, Doctor.

A Pardon me?

Q How about the air?
A This is how they are released into the air.
Q As hydrogen sulfide?
A That's right.
Q And that hydrogen sulfide has to be oxidized to sulfuric acid?
A That is correct.
Q Isn't SO_2 an intermediate step?
A That is one step, yes.
Q So you have to oxidize H_2S to SO_2, right?
A Yes.
Q So what comes out of industrial generating power plants, such as coal-fired generation plants? Out of the stacks?
A A number of different things, as I've indicated before.
Q Including just what you told me?
A Are you saying that SO_2 comes out of those stacks?
Q You're darn right I am.
A I think you would be right.
Q And there's been a great increase in the amount of SO_2 emissions from coal-fired generating plants in both New England and the west, right?
A In New England, as I have correlated with my description here in the testimony, they have decreased the use of coal but have increased the use of fuel oils and natural gas, both of which also emit SO_2 as effluents. That is not the point, however.
Q Yes, so it's not the nitrate, it's the sulfur in the fertilizer, right?
A Right.

Q How much sulfur is in a nitrogenous based fertilizer?
A I don't have those kind of numbers right at my fingertips.
Q What form would it be in? Sulfate?
A It would be in sulfite.
Q Sulfite?
A I believe so. Well, it would be in the form that would be broken down from ammonia compounds.
Q Sulfur is not nitrogen, though, is it?
A No, but it's associated with those compounds in fertilizers.
Q In what form?
A I don't recall right offhand.
Q Isn't it ammonium sulfate?
A Yes.
Q What happens to sulfate in the soil? Is it reduced to hydrogen sulfide?
A Yes, it is.
Q In what kind of soil, agricultural soil?
A Yes.
Q You could probably refer to that book that I handed you. You could see the amount of ammonium sulfate added. Do you want to take a look at that? For the nation as a whole?
A What page would that be on?
Q I think it's 203 -- 2 or 3, pardon me.
A I don't have those pages in this report.
Q (HANDING PAGES TO WITNESS) Do you see that figure, Doctor?
A Yes, I do.
Q How much is it?
A For what year are you referring?

Q Now, that figure is around 946 million tons?
A For what year are you referring?
Q '73 -- just a table there.
A 952,828 tons.
Q How much sulfur is in that?
A I would not be able to figure that out just from those figures.
Q Take a look for the New England region.
A Do you know what page that would be on?
Q I think it's 2 pages beyond this. I think it's 8.
A Yes. 260 tons.
Q Let's take the middle Atlantic and the south Atlantic. That's about an additional 25,000 tons, isn't it?
A What page would that be on?
Q 9 or 10. You've got the book; I don't have it here with me.
A No, but I thought you might have some notes as to where the figures may be. Page 9 is still the New England states, and 10 is just considering Maine.
Q Just keep going, you'll come across it, I'm sure. I think it's a table there at the front.
A You say the middle Atlantic states?
Q Right.
A 10,319.
Q Okay. That's the number that I have, and the south Atlantic -- let's assume that it's 15,661. It is.
A Okay.
Q Now, let's look at Montana, which is in --
A The Mountain States. You're considering now just one state in comparison to an area or region?

Q Just look at Montana. It's in that region. Why don't you look at it from the region?

A Okay. Montana for 1973 had 6,146 tons.

Q And the Mountain States region was 176,467, right?

A That is correct.

Q The total fertilizer consumption in '73 I'll represent to you was 285,000 tons of sulfur in the U.S. Does that seem about right?

A Yes.

Q And that's about 575,000 tons of SO_2 if it was all converted to SO_2, right?

A If it were all fertilizer SO_2? Is that what you said?

Q If it were all converted from sulfur to SO_2. If you converted 285,000 tons of sulfur to SO_2 it would be 575,000 tons of SO_2, wouldn't it?

A Yes, that's right.

Q What contribution is that, Doctor, to the total of the other sources emitting SO_2 nationally?

A Nationally it would be a relatively small contribution.

Q In the order of what percent?

A I wouldn't know that right offhand.

Q Could you estimate?

A I wouldn't like to right offhand.

Q Wouldn't that be for New England states about 200 tons of SO_2?

A If you say so.

Q Well, do you want to do the math on it? Do you want to accept that or do you want to do the math?

A No, I'll accept that. If you say so, fine.

Q Okay. Do you think that that is more likely the sulfur rather than the nitrogen in the New England states, causing this problem?

A I think probably it would be a combination of both factors. You have to consider the fact that in this correlation that I have drawn here I have not by any means excluded the fact of total sulfates as being a contributing factor.

Q What do you think would be the proportions?

A I would not like to venture a guess.

Q Let's take the New England states, or the New England region, which are those same states that I read to you before, Maine, Vermont, New Hampshire, Massachusetts, Rhode Island and Connecticut. In 1973 the total nitrogenous fertilizers were 46,509 tons. SO_2 in the fertilizer -- 1,359,995, which would represent emissions from all sources in those states.

A I think here it's particularly important to point out what type of emissions you're talking about.

Q SO_2.

A You're talking about SO_2 resulting from fuel that is noncoal; in other words, fuel oil and natural gas.

Q All fuels that include coal.

A That would include coal, and coal would be a very, very small proportion.

Q What order of magnitude, Doctor, for the coal being a small proportion, and would it be different whether it came from a coal plant or another type plant as long as it's SO_2 when emitted?

A Well, if you go on that basic assumption, then you don't

understand the basic concepts relative to the formation of acid rain.

Q I think --

A The point in question here is simply the fact that when fuel oil or natural gas is burned, a smaller percentage of SO_2 is emitted than would be emitted from a coal source. However, you do have a very, very low percentage of particulates associated with those fuels, and because of the low number of particulates it is very easy for acid rain to be formed in the atmosphere. There is no ad or ab sorption of the SO_2 or the forming acids on those particulates associated with those types of fuels. That is not the case with the use of coal.

Q Would it surprise you, Doctor, to learn that since 1940 the total SO_2 from steam electric utilities has more than doubled?

A No, it would not.

Q And that the total SO_2 from all sources has stayed about the same?

A That doesn't surprise me, no.

Q Then I suppose the most basic question I can ask you is, does an SO_2 molecule care where it comes from when it gets into the air to be oxidized?

A Certainly not.

Q The molecules don't give a damn, do they?

A That's right. Where they end up makes a big difference.

Q Right.

A So if you have a large number of particulates, as I have cited as an example, they will end up being adhered or absorbed to those particulates and will possibly be, depending

on the type of particulate and the nature of particulate, either be neutralized or bound to that particular particulate.

Q Or oxidized on the surface of it?

A That's right.

Q And what does that mean?

A What do you mean, what does it mean?

Q What happens when you oxidize on the surface?

A It would form acid. That's exactly what happens. It oxidizes on the surface, forms acid, and depending upon the nature of the particulate, that acid may be neutralized.

Q But the potential for acid formation is certainly very great, isn't it, Doctor?

A Well, it's certainly very great in the east, as I've pointed out. I have examples of acid rain in the east.

Q And the sulfur there is less than the total -- the total sulfur emitted in the northeast is less than the west, is that what you're telling us?

A No, certainly not.

Q It's just the opposite, isn't it?

A The amount of sulfur produced in the northeast is much greater than what is produced in the west.

HEARINGS EXAMINER: Are you going to have some more cross?

MR. SHERIDAN: I've got lots more.

HEARINGS EXAMINER: Okay, do you want to keep going or do you want a recess?

MR. SHERIDAN: I'll give my throat a break.

HEARINGS EXAMINER: All right, we'll recess till 1:30.

(RECESS AT 12:02 P.M.)

Following the luncheon recess, the hearing reconvened at 1:35 P.M. on January 29, 1976.

HEARINGS EXAMINER: Are you ready?

MR. SHERIDAN: Right.

HEARINGS EXAMINER: Very well, you may proceed.

CONTINUATION OF EXAMINATION OF DR. PETER R. EDMONDS

Cross, by Department of Natural Resources and Conservation

By Mr. Sheridan, (continuing):

Q Dr. Edmonds, I forgot to ask you this morning whether or not you had taken any pictures of the vegetation that you sampled around the Corette plant in Billings?

A Yes, I have.

Q Do you have them with you?

A No, I do not.

Q About how many pictures did you take?

A Oh, I imagine about 50 pictures. I ended up with a couple boxes -- I took a couple rolls.

Q What kind of species did you take pictures of?

A Predominantly ponderosa pine; I'd say that a little bit more than 50% of my photographs were of ponderosa pine.

Q Are these close ups or full tree views?

A Both.

Q When you were making your observations insofar as premature needle casts was concerned, how many samples did you take?

A I don't recall right offhand.

Q Did you physically remove the samples from the tree?

A No, I did not.

Q One thing that I didn't get tied down this morning was who the individual was who said there was a correlation between nitrogen-containing commercial fertilizers and acid rain in New England.

A That was in Likens & Bormann.

Q What did Likens say with regard to what the acid rain was probably caused by?

A He said that as I have said in my testimony that the acid rain probably is caused by increased industrialization; that it is caused by the release of SO_2; and it is associated with the increased use of fertilizers.

Q It was his belief, wasn't it, that more probably than not the primary causative factor was NO_x and SO_2 from power plants?

A I don't recall that it was specifically associated with power plants. He said industrialization and he indicated that SO_2 was a possible component, as were these other factors. He indicated that to a large degree it was because of the burning of nonprecipitate type of sulfur content fuels.

Q What does Ode'n consider to be the most serious acid gas in the increased acidity of rain?

A SO_2.

Q We had some discussion this morning on Dr. Frohliger. Who's he working for?

A He's at the University of Pittsburgh.

Q His acid rain studies have been done in conjunction for what public utility?

A I don't recall right offhand.

Q Isn't it true that Frohliger's only work on acid rains has been

as a consultant to the Mongongalela-Allegheny Power Company?

A That I don't know for sure.

Q You wouldn't dispute it, though, would you?

A Well, I know that he has done work for DeNardo & McFarland, for example, as this one publication that you have here; in comparing that one publication to mine it should be noted that that publication is a 1963 publication, whereas mine that I have referred to in reference to methodology is a 1975 publication out of "Science." This is the specific report that you have cited as being in reference to Denardo & McFarland's study.

Q No, you're wrong, Doctor. All I asked you was to determine the rain collection apparatus off that study.

A What study?

Q The 1963 paper you have in front of you.

A You mean the 1973 paper?

Q Pardon me, '73.

A In other words, that's why you asked me to look at it?

Q That's right.

A I assumed when you showed me that that was specifically the same publication that I had from "Science."

Q Did you know that Dr. Frohliger was the consultant to the Mongongalela-Allegheny Power Company in a damage action for acid rains, amounting to over $4 million in claims?

A No, I had no knowledge of that fact at all.

Q Doctor, would you say that more nitrogenous fertilizers are used in the central part of the United States, including the Great Plains, than, say, the states of Iowa, Texas, Montana?

A I wouldn't know right offhand whether that was the case or not. I don't know to what extent fertilizers are used in all of those areas.

Q Would you expect more fertilizer to be used in the Great Plains region of the United States than in New England?

A On the basis of just unit area alone, I would, yes. You could take New England and put it into Montana several times.

Q What soil surveys have you conducted personally on the soil in and around Colstrip?

A Soil studies were done in association with the type of vegetation that grows on those soils; in other words, delineating specific vegetative type. Studies were done as to the chemical contents of those soils. That's all that I'm aware of.

Q Is the presence of calcium carbonates and free magnesium in the soil a function of depth?

A A function of depth?

Q Yes.

A I would say not.

Q Dr. Edmonds, on page 9 of your statement you say, "Current information strongly indicates that little SO_2 is actually converted to sulfate in the atmosphere and that power plant SO_2 emissions very likely contribute little to acid precipitation production." Do you have a citation to support that statement?

A Where are you reading from?

Q Page 9, line 3.

A Line 3?

Q Right.

A Oh, I'm sorry. I'm on the wrong page. As I recall, there was a specific reference used for this statement, but I do not at this point in time recall specifically what it was.

Q Isn't it true, Doctor, that approximately 80 to 85 percent of the total SO_2 emitted into the air in the United States comes from steam generation plants?

A That is true.

Q And if you can't make SO_2 into SO_4, why can't you make NH_3 into NO_2?

A I don't see the relationship of your question. I don't follow you.

Q Aren't you really talking, Doctor, on line 3 of page 9, about the rate of conversion from SO_2 to SO_4, rather than the absence of that conversion?

A I'm talking here about -- that the information that has been accumulated casts doubt upon the fact that the complete conversion of sulfate from SO_2 power plant sources is an actual major contributor to the acid precipitation condition.

Q The most prevalent source of SO_2 in the United States emanates from coal-fired generating facilities, doesn't it?

A That is correct.

Q What other source shows a greater propensity to correlate with acid rain?

A Well, if you're assuming that acid rain is specifically caused by just the constituent of SO_2 and its conversion to SO_4, then that would be a very good place to look. What I'm questioning is whether that actually is the major constituent

that formulates the production of acid rain.

Q The strongest evidence to date indicates that SO_2 is indeed that factor, doesn't it?

A I have presented my logic in the testimony as provided.

Q I'm not asking for your logic. I'm asking what evidence there is in the scientific community, Doctor.

A The current evidence is that SO_2 is a contributing factor, as I have so stated.

Q Doctor, you make a point on page 17 that "Airborne dust which is common in the western United States reacts with sulfate, nitrate and carbonic ions in the atmosphere changing them to neutral relatively harmless salts." First of all, I ask you, Doctor, as a chemist, or with your training, if there is any such thing as a carbonic ion?

A First of all, I would like to state that I am not a chemist, and then I would like to ask specifically where you are reading from so I may follow you, please.

Q Line 17, page 9, starting at line 17, "And third..."

A Now, what is your question, please?

Q What's a carbonic ion, if there is such a thing?

A What I'm referring to here are compounds such as calcium carbonate that would normally be found in the dust.

Q Those are carbonate ions, not carbonic ions, aren't they?

A That is correct. They are derived from the carbonic ion derivative.

Q In making that statement about airborne dust, Doctor, did you review the NOAA reports on particulate distribution in the United States?

A Yes, I did.
Q Isn't it a fact, Doctor, that around Colstrip the dust is not relatively common?
A I don't recall seeing that statement in the report. Another report that I have seen indicates that in that particular area dust is quite a problem.
Q What report is that, Doctor?
A I am trying to recall; I don't right offhand.
Q What measurements did you make in that area, Doctor?
A I've only made visual observations and gritted my teeth.
Q What's that from, the SO_2? (Laughter) Which months have you been to Colstrip?
A Since the initiation of the project?
Q Well, since you were hired.
A Since I was hired by Westinghouse?
Q No, hired by the applicants to work on the Westinghouse team.
A Which months have I been to Colstrip?
Q Yes.
A I find that very difficult to answer right off the top of my head. I really do not recall. There have been many trips to the area.
Q How many days would you say you've spent at Colstrip making your analysis?
A Total number of days?
Q Right. Full days.
A Yes. I have to approximate the number. I would say roughly 25 or 30 days.
Q What times of the year did you go there most often?

A All times of the year.
Q Would you explain for me what the environmental conditions are that are so different between those in eastern Montana and those in New England and northern Europe?
A One of the conditions as I have stated is the amount of rainfall. Montana in this particular area is considered to be semiarid, with an annual precipitation approximately averaging 14 inches per year. The predominant precipitation during the year period, about 57% averages out to come within a 5-month period between March and July. The contrast to the New England, northern Europe area is that they are not arid, much more humid areas, much higher rainfall, as I have indicated. Their very major difference is because of a number of factors -- the type of vegetation that grows in Montana in this particular area is entirely different, relative to species composition and density, and the number of industrial developments and sources for SO_2, as well as other effluents, is much more developed in the northern part of Europe and New England than it would be here in Montana. Another major difference is the distinct difference in relationship between vegetative cover and type of soils that they grow in, and the availability of the soils to form dust.
Q Is that about it?
A That's some of the differences. These come to the top of my head right now.
Q Right. You say 57% of the rainfall in Colstrip occurs in the 5 months from March through July, right?
A That is correct.

Q About 80% of that rainfall, of that 57%, falls in the months of May and June, doesn't it?
A That's about right, yes.
Q And that's at the time when the plants are the most sensitive, isn't it?
A I think that would depend upon what specific plants you were talking about.
Q Well, let's take your grasslands, your grasses. What is the most predominant grassland in there?
A I didn't hear that.
Q What's the most predominant grassland in the Colstrip area?
A All of a sudden, blank -- my mind has gone blank, I'm sorry. I could think of it in a minute, but --
Q It's Western wheatgrass, isn't it?
A Yes.
Q In the phenology of Western wheatgrass, when is that grass most critically dependent upon conditions that will allow it to reach maturity?
A I don't know.
Q How about Bluebunch wheatgrass?
A The same.
Q How about Red threeawn?
A The same.
Q How about Blue grama?
A I can't say that I specifically know of one particular time for all of these species when they are particularly sensitive.
Q Okay, I'm going to ask you the following, Doctor, and if at any time you can tell me when they're most critically dependent

upon good conditions in their phenology, just sing out: Japanese Cheatgrass, Threadleaf sedge, Sedge, Prairie junegrass, Kentucky bluegrass, Sandberg bluegrass, Tumble grass, Sand drop seed, Needle-and-thread, Green needlegrass. Do you know the answer to any of that?

A I would say as a general rule for grasses in general that they would be more sensitive to environmental conditions in general at the initial stage of their emergence than they would be later on.

Q Well, isn't the time when they're nearly mature that they're most sensitive to foreign intrusion by particulate or gas?

A When they're nearly mature?

Q About 40% in their phenology?

A Generally so; yes, I would say that.

Q And when do you think for those species I listed that that time occurs at Colstrip?

A That would be in the early spring to midspring.

Q Now, first of all, what's phenology?

A Phenology is the study of the development of plants through a period of time for their initial development, their form and structure through that development.

Q When are the following species most sensitive to airborne pollutants? Silver sagebrush, Terrigan sagewort, Fringed sagewort, Broom snakeweed, Skunkbush sumac, and Wood rose?

A At the time of their maturity.

Q When's that at Colstrip?

A You're talking about perennial vegetation --

Q Shrubs and half-shrubs, yes.

A Yes, and the period when they would be most sensitive is any time after the first year; in other words, when they are mature.
Q When do they mature?
A The period of time for maturation?
Q No, the month of the year when they're mature.
A I would say midsummer.
Q And they're in the process of maturation until midsummer, aren't they, because they start growing in about March?
A Yes.
Q What do you mean by midsummer, July or June?
A I would say July.
Q One particular consideration for your grasses in the vicinity of Colstrip's facility, which I listed for you earlier, is that if they do not mature or do not have good growing conditions during their maturing period in the spring, they don't make it for the summer, do they?
A That depends entirely upon the sensitivity of that maturation.
Q Well, isn't it more sensitive at that time, though?
A Yes, I would agree with that.
Q And at the time the plants are most sensitive is also the time that they are more sensitive to acid rains, isn't that true?
A I have no evidence to indicate whether that's true or not.
Q You've never inquired of that or attempted to make an assessment of that phenomenon, have you?
A In my assessments of that phenomenon that particular point has not come up, nor have I seen it documented anywhere.

Q Wouldn't that strike you as being rather important to the cattlemen who graze herds in the vicinity of Colstrip?

A If that were to be the case I would say that it would have some importance if acid rain were a problem there, but as I have indicated, I haven't seen that documented. I don't know in fact whether there has been detailed experimentation and credible experimentation done to document that fact, and secondly I don't know whether the problem of acid rain in that particular area would be a real problem that would have to be considered.

Q How many tons of SO_2 are going to be emitted per year at the Colstrip facilities 1 through 4, Doctor?

A How many tons?

Q Yes, of SO_2.

A I don't recall the number right offhand.

Q How about an estimate?

A I would not like to make an estimate.

Q Would you even consider it?

A I considered it relative to concentration, relative to duration; obviously I considered it because I talked about it in my statement.

Q Doctor, you have not had any experience in diffusion modeling yourself, have you?

A Only to interpret the results of those models as conducted by qualified meteorologists.

Q And you, sir, have had no training in meteorology that would allow you to determine whether or not the particular models adapted to the Colstrip site, do you?

A Not specific training, no.
Q It's your job to estimate terrestrial impacts, isn't it?
A That is correct.
Q What are forbs?
A What are forbs?
Q Right.
A Forbs are herbaceous plant forms.
Q What is their function?
A In life? To grow.
Q That's right. Beyond growing, what do they do for the ecology of a region?
A What do they do to the ecology of a region?
Q Right. What are they good for?
A They're used for forage in a number of cases.
Q By what, grazing animals and birds?
A Grazing animals.
Q When does Western yarrow bloom or commence its most active period of growth during the year at Colstrip?
A I believeit's in the late spring.
Q How about ragweed?
A About the same period of time.
Q Louisiana sagewort?
A I believe that's at the same time, also.
Q What happens, Doctor, when you have no precipitation or very little precipitation during the growing period for these forbs?
A If you have absolutely no precipitation, in other words a completely arid condition, I would say that the growth of

the forbs would be stunted.

Q Do those forbs respire?

A Respire, you say?

Q Yes.

A Of course.

Q When are they most susceptible to injury from exposure to airborne pollutants?

A As I recall, I believe it's during that same period, as I have indicated previous to this.

Q Have you ever done any research yourself to determine when they are most susceptible?

A Specific field research, no.

Q You make an interesting statement, Doctor, on line 26 of page 10 of your statement, "My personal observations indicate a complete absence of such damage in the areas examined," referring to acid rain. Now, you told me earlier that you had visited Helena.

A Helena?

Q Yes, East Helena?

A Yes.

Q And you've been to Billings, right?

A I still can't hear you. You're a little bit too close to your mike.

Q And you've been to Billings?

A Yes, I have been to Billings.

Q Have you ever visited Anaconda?

A As I indicated previous to this, no, I have not visited the smelter there.

Q Have you ever visited the area around the Hoerner-Waldorf plant in Missoula?
A No, I have not.
Q Do you know at this time who the two largest emitters of SO_2 in the State of Montana are?
A Well, Anaconda is one of them, and I assume from the way you phrase your question that the Hoerner-Waldorf plant is the other, but I don't specifically know for sure, no.
Q Wouldn't that be a nice thing to look for if you're going to try and determine whether or not there is acid rain damage in Montana?
A I am particularly interested in whether there is acid rain formation around power plants, and that is one of the primary things that I was looking for, and I was looking for it in conjunction with those areas that I'm already familiar with and would be more readily able to establish some basic criteria.
Q Well, you're not going to tell me that the weather conditions in Colorado are the same as they are around Colstrip in the State of Montana, are you?
A Certainly not.
Q Then, Doctor, why didn't you go see the two largest emitters of SO_2 in the State of Montana?
A I just didn't happen to conduct my studies there.
Q Well, you know that they emit SO_2 and you know that SO_2's going to be the major effluent from the Colstrip plants, don't you?
A A number of sources emit SO_2. I'm particularly interested in

sources that would utilize coal, coal specifically from the Colstrip area; those sources that I'm familiar with, such as the J. E. Corette plant, I utilized in the conducting of my experiments.

Q Well, Doctor, we already have established this morning that molecules don't care, do they?

A The proportional amounts of SO_2 produced and the sulfur content of the coal that is burned in the production of that SO_2 does make a difference to me, yes.

Q Can you tell me, Doctor, whether or not the Anaconda Copper even now is going to be producing more or less SO_2 than the Colstrip units 1 through 4, combined?

A I am not specifically familiar with the data associated with the Anaconda copper mine, and I would not like to comment on it because of that fact.

Q It'd sure be nice to know, though, as a scientist, who's going to be putting out amounts of SO_2 in quantities most closely equal to that of Colstrip, wouldn't it?

A In my studies I have made them for as reasonable an amount of time and facilities that I had to conduct my studies -- I've made them on power plant emissions that I consider to be relatively similar in area and extent, and also coal content -- sulfur content of coal -- to what I would expect to find in the Colstrip area. As a scientist I fully realize that I cannot study the world, and in that sense I tried to relate it specifically, or as close as possible, to Colstrip.

Q Well, how about Illinois? You studied coal-fired plants there, didn't you?

A Yes, I have.

Q What percent sulfur content is burned in that coal?

A 3.5%.

Q And what's the sulfur content alleged to be for Colstrip coal?

A I understand, when I had done my analysis and when I made my conclusions, that the coal that would be burned there would be less than 1% coal, and my conclusions are based upon that fact. I obtained that information from the findings of fact and conclusions of law.

Q That's pretty important, though, what the sulfur content is in the coal, isn't it?

A Pardon me?

Q Isn't that pretty important to you to know what the sulfur content is of the coal?

A If there are no other criteria that would come into play in that type of an analysis, I would say the sulfur content of the coal is one important criteria. However, when you limit the amount that the sulfur content of the coal can contain, then I would say that that is a major criteria to be considered.

Q Well, Doctor, recognizing that molecules don't care, if 500 tons of SO_2 a year were being kicked out of, say, Anaconda, and 500 tons of SO_2 were being kicked out of Colstrip in a year, would you rather, for comparison purposes in the Montana environment, study or search for possible acid rain damage in the vicinity of the Anaconda location, or would you rather go study it in Pennsylvania, Illinois or somewhere

else?

A I think it's very important to relate as specifically as possible those particular aspects of the study to the situation that you would find at Colstrip. The simple derivative or simple analysis made just upon the number of tons of SO_2, seeing as how molecules don't care, is much too simplified a criterion to go with when you're doing a complete analysis. For example, where those molecules that don't care very much go to is a very important criteria; the size of the stack and the distribution of those molecules over what specific area is another major factor that should be considered.

Q Do you have many ponderosa pine in Illinois?

A I can't say that through my intensive studies in that area I have come across one species of ponderosa pine.

Q You have not come across one, have you?

A Not in Illinois.

Q You don't have lodgepole pine, either, do you?

A No, lodgepole does not grow in Illinois.

Q Nor the limber pine?

A That is correct.

Q All three of those are indigenous to the Colstrip site, aren't they?

A No, the only pine that I'm familiar with in the Colstrip site would be ponderosa pine.

Q No limber pine?

A I haven't found limber pine or lodgepole pine, except starting around in the Helena area.

Q You make the statement, Doctor, on page 11, line 4 through

line 6, and your statement relates to acid precipitation in Montana; the statement says, "I have carefully reviewed the evidence used as a basis for such claims and found the evidence to be completely nonsupportive." Doctor, as I understand it, you have never observed the histological studies, the infrared photographs, the photographs for the vegetative analysis conducted on ponderosa pine in Montana by Dr. Gordon, is that right?

A I have reviewed all of the information made available by Dr. Gordon to me, although it was incomplete, as well as additional information in relating the arguments that have been developed in the DNR EIS, specifically in reference to acid rain, and have found that the evidence that he has put forth in that particular document are nonsupportive, yes.

Q So you're sitting back in Pittsburgh saying, "You didn't send me everything you've got, so I'm not going to do anything else." Isn't that it?

A That is not it whatsoever. As I have indicated I have used other sources of information, and in analyzing the information that he has sent to me, I have pointed out one example here where it is nonsupportive, or where it does not make sense.

Q And Doctor, it doesn't make sense to you to go take a look at the chemical analysis, the histological slides, or the photographic slides that Dr. Gordon has, is that right?

A I am familiar with those slides that Dr. Gordon has; I've heard him talk about those particular slides on a number of occasions.

Q Yes, but you've never really looked at them, have you?

A Of course not.
Q How about Dr. Hindowi? Have you ever talked to him about his studies on acid rain?
A No, I haven't.
Q You know that he's done a lot of work. In fact, he's published on the subject, hasn't he?
A He's done some work on the subject, yes.
Q Have you ever thought of inquiring of him?
A I have utilized some of his papers in the preparation of this testimony.
Q The only people with whom you've conversed have been those who have been employed by power companies who were defending themselves against claims for acid rain damage in and around their coal-fired power plants, isn't that true?
A No, I would not say that is true at all.
Q All right, let's take A. Clyde Hill. Who's he employed by?
A He works as a university personnel -- of a university. He is on occasion employed by a utility.
Q Yes, Four Corners, isn't it?
A Yes.
Q And then Dr. Frohliger?
A You indicated to me that he was employed or has done at least some work for a utility. As I indicated before, I was not aware of that fact.
Q Who does Dr. Wood work for?
A Dr. Wood?
Q Right.
A I believe that he has done some analyses and some work for a

number of different utilities, as well as his own separate studies through the University of Minnesota.

Q Doctor, on page 11, line 8 through line 11, you give us some discussion about the fact that available evidence indicates that conifer needles can be damaged by fluoride and not by the acidity in the case of hydrofluoric acid. If one puts H_2SO_4 in a glass at a pH of 1, would it etch the glass?

A H_2SO_4?

Q Right.

A It would not.

Q Would HF acid at a pH of 1 etch the glass?

A Yes.

Q Were you aware, Doctor, in the published literature that it is possible to distinguish by histological studies the difference between SO_2 exposure and HF exposure?

A I have read literature where it has been indicated that there is a methodology employed that would again indicate the difference between the two.

Q Have you ever undertaken to educate yourself on that subject?

A As I have indicated, I have read the literature.

Q Have you ever seen it done, visited a lab where it's being done?

A No, I have not.

Q Are you saying by your comment that the damage being caused by fluoride is a result of the fluoride ion contributing to toxicity?

A I'm saying here in this statement that it is not reasonable to assume that the damage that's done is due strictly to

the pH or ion activity within the particular case that we're discussing here, simply because there's more damage that is being caused at a higher pH than at a lower one. In other words, a pH tending more towards neutrality -- a less acid condition.

Q Then going on, Doctor, to line 19, you state, "Possible acid precipitation damage to Christmas tree plantations near Mt. Storm in the Maryland-West Virginia area was carefully examined from 1969-73." What type of a plant is located in the vicinity of those Christmas tree plantations?

A There are a number of plants located there, all of them fossil-fuel plants.

Q Yes. What do they kick out in the air?

A The normal constituents that you would find with a coal-fired plants -- SO_2, NO_x and particulates -- effluents.

Q Those are coal-fired plants, aren't they?

A Yes.

Q And you say it's only possible acid precipitation damage?

A I have not seen any specific evidence that says that they are -- that the damage that has been demonstrated to be there is specifically caused by acid rain.

Q You talked to Dr. Wood, I assume?

A I certainly have, yes.

Q Didn't you know that Dr. Wood and Dr. Gordon both testified in the Federal Court in Alexandria, Virginia, and the Court awarded damages for acid rain?

A I know that they both testified. I am not aware of any damages or any awards being made for damages. I'm not aware

of the fact that any award, if made, was made simply because of a proven fact that acid rain had caused that damage.

Q You never talked to Dr. Wood about that, hmm?

A I have spoken to Dr. Wood about his studies, yes.

Q He never told you about that, though, did he?

A I don't recall right offhand his mentioning that specific thing.

Q Did he ever tell you that more than a million dollars had been spent for scientific research in that area?

A I don't recall that statement being made, either.

Q Did he ever tell you that the companies have paid over a half million in damages?

A I never discussed any of those subjects with him; I wasn't interested in any of the monetary transference in that area. I was interested in the validity of his studies that had been done there and what the real cause and effects were.

Q Well, that's the problem that a lot of ranchers and a lot of residents are worried about, too, Doctor. The problem is an economic problem, not cause and effect.

A I am worried about specifically what the conditions would be there, what the overall effects would be because of these conditions in that development of the plant, and I have come to the conclusion, as so stated in this testimony, that I see no reason for concern.

Q You're not concerned?

A Based on the information presented here I do not find it reasonable to assume that an adverse condition would be derived at through the operation of that plant facility.

Q Having done no research on site?
A I've done considerable work on site, and know the area and --
Q You have been to Mt. Storm?
A No, I'm not talking about Mt. Storm.
Q Well, I am.
A I'm talking about Colstrip. All right, fine, let's talk about that.
Q You haven't done any research on site there, have you?
A No. As I have indicated, I have not yet been there. What I have done is to interface with those people that have done studies there.
Q What does "interface" mean, talk?
A Interface means to talk with them; it means to review their specific work and study that they have done there, which I have done for the work of Clancy Gordon, as well as Dr. Wood.
Q Interface without looking at the slides or photographs in detail, or discussing those with the individuals, and without ever learning of the fact that there had been damages awarded; is that your idea of interface?
A I don't know what awards of damages have to do with scientific studies. I tend not to get bogged down with those kind of trivia. What I am concerned about is what the validity of the specific studies were, and whether the real effects that have been cited for those areas are true, valid.
Q Do you consider damages that would ruin a financial operation to be trivia?
A What I consider to be important there is whether or not there is true damage to vegetation that is specifically caused by

the power plant.

Q To the 95 degree of confidence, right?

A Do you want a positive answer on that?

Q I assume so.

A Your assumption is correct.

Q Turning, Doctor, to page 12 of your statement, have you had any training in entomology?

A Would you repeat that, sir?

Q Have you been trained in the study of bugs?

A Entomology, you mean?

Q Yes.

A I have not been specifically trained in that as a primary expertise, no.

Q You make the statement that "the Mt. Storm area strongly indicates that the observed damage was due to a biological causal agent (thought to be mites) rather than any association with acid precipitation."

A As I interpret the available evidence for that, that conclusion has been reached by others, and I agree with that conclusion.

Q Did you review Dr. Farrier's work? F-A-R-R-I-E-R?

A I don't recall right offhand that name. It doesn't ring a bell with me; no.

Q He did some work on some adelgids and their effects upon the scotch pine.

A Okay.

Q You're not familiar with that work?

A I'm not familiar with that particular study.

Q How about the work of Dr. J. R. Baker?

A That does ring a bell.
Q How about the work of Dr. R. F. Anderson?
A No.
Q Did you know that Dr. Anderson concluded after studying the question at Mt. Storm that chemical injury, particularly from particles, was the probable cause of basal needle spotting and needle deworking in scotch pine near Mt. Storm?
A I am not familiar with that particular statement. I am, however, familiar with the fact that there are a number of factors operating in Mt. Storm, chemical injury being one of them. One of the primary sources of that injury is the extensive use of herbicides on the vegetation, and insecticides. Another major factor at play in Mt. Storm is the fact that it is extremely windy and the vegetation there has suffered because of that particular physical aspect. Another primary factor at play at Mt. Storm is that there's an extremely high water table and very, very poor drainage. The overall consequence in the number of these factors is that vegetation there is generally very scrubby, marginal, and relatively susceptible to any additional stresses which may be placed upon it.
Q And that's why thousands of acres of Christmas trees are planted there, right?
A Why are those Christmas trees planted there? I have no idea.
Q Dr. Edmonds, who was the scientist that you talked to about mites, who studied the problem at Mt. Storm? The entomologist?
A The entomologist himself, I don't recall his name right offhand.
Q Would it surprise you, sir, if I told you that the only four

who did I just named? I'll name the four -- Dr. Gordon --
A Is Dr. Gordon an entomologist? That's an amazing accomplishment in a very short time. By entolomogist you do mean one who has had specific training in that field?
Q Yes. Say three.
A Okay. As I recall, a discussion I had with an entomologist that was in association with Dr. Wood and Pennypacker -- this was at the Boston meetings of the National Air Pollution Control Association -- I do not recall his name right offhand.
Q At least he didn't publish, did he?
A I have no idea. I have not read any of his specific publications.
Q But based on that back room conversation at the conference --
A It wasn't in the back room, it was right there in the --
Q Okay, I'll give you the main auditorium, then, Doctor, but you haven't bothered to read any papers on this. You haven't made any investigations yourself, and just word of mouth makes you say, as a scientist, that intensive research into this phenomenon occurring in the Mt. Storm area strong indicates that the observed damage was due to a biological causal agent; is that what you call the scientific method?
A I call a very detailed review by a nationally known scientist and his study over a period of years in Mt. Storm to evaluate the effects in Mt. Storm, and what the operating agents were in that area, and I think it reasonable that with such a study done by himself and his associates to assume that the methodology was correct, that the assumptions made in his statements are correct, and that there is validity to his overall statement

of that fact, yes.

Q Yes, but you can't answer for me anything about three doctors, three scientists who studied the question at Mt. Storm.

A Who studied the specific adelgid mite situation at Mt. Storm?

Q Right.

A Those particular people that you have named off, I do not recall having read any of their papers; no. I have indicated that before.

Q You can't recall the name of any other entomologist, either, can you?

A That's right. I think it should be pointed out here, too, that this general insect type, the adelgid mite, has not been specifically identified, has not been found, but evidence for its presence is indicated through the studies, and the only thing that Dr. Wood or myself or anyone else has clearly said is simply the fact that the damage associated there is through some other causative agent, other than acid mist.

Q And so you're sort of coming up here and telling us that that's your opinion, although you haven't done any study of it or talked to the people on the other side?

A That is my opinion as formulated through a study of the available literature and talking with individuals who have been associated with studies in that area.

Q You missed three of them.

A Well, I'm sorry about that. I can't get them all, I suppose, but we keep trying. I have talked to those people that are specifically and most importantly involved.

Q Well, I don't know if they're most importantly involved or not.

A Well, it's the people that did the study; it's the main people that controlled the study, and they were in charge of it and designed it and worked there on the project.

Q Are you telling me that Dr. Farrier and Dr. Baker and Dr. Anderson aren't important?

A No, I am not. I have no way at this point in time of evaluating whether they are or not.

Q But you can't even give me a citation to a single article that would support you, can you?

A By those particular authors?

Q Yes.

A No. As I've indicated to you before -- need I repeat it? I have not read their material.

Q Yet you're giving a scientific opinion here today without having read that material?

A I'm giving a scientific opinion based on the available literature to me and talking to the people that have conducted the major studies --

Q But didn't you --

A -- I'm not through yet, excuse me -- that have conducted the major studies in that area.

Q The literature to which you cannot give me a name, the authors of which you cannot give me a name.

A The people that have done the major work in that area are Drs. Wood and Pennypacker and Dr. Gordon.

Q Tell me if Dr. Wood is an entomologist?

A He is not.
Q Is Dr. Pennypacker?
A He is not. Dr. Wood is a pathologist.
Q Did Dr. Wood ever tell you that he did histological studies to determine whether mites or insects had damaged needles?
A Dr. Wood himself has not done histological studies, but he has worked in association with anatomists, qualified anatomists, who have done histological studies -- in other words, people who are indeed anatomists and are qualified to do histological studies.
Q If you drop down to line 15 on page 13, you say, "It is likely that the mouth parts of a small insect -- and in brackets you have (mite) -- penetrated through the immature fascicle, inflicted damage and obtained nourishment." Isn't there a difference between a small insect and a mite?
A By putting mite in parentheses here, I was referring back to the particular study which I had in reference before that; in other words, any small insect, and as I have indicated we don't know specifically, or it is not known specifically, what insect, but an adelgid type, such as a mite.
Q Well, a mite's not an insect, is it?
A It certainly is.
Q It is? What scientific class are mites members of?
A I don't recall the technical name right offhand.
Q So mites are munching away on the fascicular sheath, is that what you're telling me?
A Would you repeat that, please?
Q So mites are munching away on the fascicular sheath, is that

what I am to infer from your statement on page 15 -- page 13, line 15?

A It has been indicated that mites could penetrate the fascicular sheath, as well as other tissues within the leaf.

Q Do mites have jaws?

A I do believe that they do not.

Q Insects do, though, don't they?

A What I am thinking of specifically here are probing insects rather than chewing types.

Q You haven't done any studies yourself, though?

A As I have previously indicated, specific field work in that area, no.

Q Have you anywhere in the world, Dr. Edmonds, ever studied conifer needles to determine whether or not damage has been incurred by either mites or insects, yourself?

A No, I have not.

Q You also make the comment on page 13, line 27, Doctor, in relation to the claim that higher pH treatments have caused overall needle necrosis and needle casting of scotch and white pine, you say, "However, other workers have been unable to duplicate and consequently verify these results." And that's with respect to your acid innoculation experiments on developing white pine needles for Montana pine. Did you know that Dr. Hindowi has duplicated that?

A I'd like to review what I said here. What line was that?

Q Start at line 20 and just read on down off the end of the page there, on page 13.

A Yes, I am aware of the fact that necrosis has on conifer

needles been developed through the use of low pH. Specifically what that pH is I'm not sure, but I believe that pH to be somewhere around 2. I'm not aware of higher pH's causing damage; however, I am aware of other studies that have been done by other individuals with lower pH values than that that have not caused injury of any kind, not even necrosis.

Q Of course, your confidante, Dr. Wood, has been able to duplicate that, hasn't he, Doctor?

A Dr. Wood has been able to obtain necrosis in conifer needles by using extremely low pH's, being sprayed on to saturation and then dripping off, just much the same as if you would dip your hand in a strong acid and then feel very warm.

Q Do you know that Dr. Wood got the short-long needle syndrome at 4.5 to 5.5 and he has so reported it?

A I don't recall that.

Q Doctor, when you have rain water that has an acid character and that rain water lands on the soil, what happens to that soil insofar as potassium, magnesium and calcium are concerned?

A The depends on the concentration of the acid and the availability of those elements.

Q Well, let's say with a pH of 2.3.

A Well, here you're using a strong acid, and that would tend to bind up those elements.

Q It would leach them from the soil, wouldn't it?

A It could leach some, yes.

Q Hasn't that been reported in the literature?

A Yes, it has been.

Q Your last sentence in the first paragraph on page 14, line 13, based upon your answers to my questions 2-3 minutes ago, is incorrect, isn't it?

A I'd like to read that and review that portion. You say beginning on line 13?

Q Yes.

A To the best of my knowledge at this time, I am not aware specifically of any other investigators who were able to develop specifically again the long-short needle syndrome due to strong acids.

Q You don't recall that Dr. Hindowi was able to do this and Dr. Wood was able to do this?

A I was only aware of the fact that they were able to arrive at a condition where necrosis was the result of the application over a long period of time, continual application to saturation of strong acids.

Q Dr. Wood reported that fact at the Acid Rain Symposium last year, didn't he?

A As I've indicated, I do not recall that.

Q You were there, weren't you?

A Yes, I was.

Q You must have missed that, right?

A I do not know whether I did or not. As I have indicated, I do not recall that particular statement being made.

Q You'll grant us the fact, Doctor, that you recognize that large amounts of SO_2 will be emitted from the coal-fired generating facilities at Colstrip?

A Well, you talk in terms of what seems to be large quantities

on a tonnage basis. My estimates on a basis of concentration indicate that the concentration of SO_2 being emitted from those plants under full operation is quite a low number.

Q Yes, but you're talking about averages, aren't you, Doctor?

A Yes, I am.

Q Do averages kill people or do acute doses kill people?

A I am talking about maximum doses.

Q Maximum average doses?

A That is correct.

Q Let's assume that the average exposure for the year is derived by very high readings during the growing season and very low readings during the dormant season. You've got an average which really doesn't mean too much there, does it? Don't you?

A You cannot make that statement unless you are fully aware of what it is that that average is supposedly, or the extremes around that average is supposedly affecting; in other words, what particular species, the sensitivity of that species to SO_2, the length of time that the species is subjected to a fumigation at that particular concentration, and also the other physiological effects that would be associated with the growth of that plant.

Q Let's say the dose is pretty high during the period of the phenology of a Western wheatgrass when it's most sensitive to pollutants.

A When you say "dose" do you mean concentration or do you mean period of time?

Q Concentration.

A If the dose, as you say it for concentration, were high,

whatever that is, it would again depend upon a particular species that you're talking about, and the duration of time that that dose was maintained.

Q Averages can be very misleading, can't they, Doctor?

A Averages do not tell you what the extremes are.

Q And the extremes are those -- normally we find that they are most dangerous, isn't that true?

A Again, it depends on the particular situation at hand.

Q Well, isn't that generally true, though, Doctor?

A I would say as a general rule in nature, yes.

Q You don't consider yourself a wildlife biologist, do you, Doctor?

A No, I do not.

Q You're merely reporting some things that you've picked at random about concerning the effects of effluents upon humans and wildlife on the bottom of page 15, continuing on to page 16, right?

A Not exactly. What I have attempted to illustrate here are those levels that would normally be associated with the effect of some type of detrimental reaction. I've tried to correlate what those normal concentrations and durations of time would be to cause such a deleterious effect, and I have tried to correlate that to those extremely low levels that would be associated with the operation of the Colstrip units to show that there really is no relationship between the two.

Q Are you seeking damage in the sense as you define it on page 16?

A Where specifically on that page, to save me some time, did I

mention that word?

Q Sure. Line 8.

A What I've said in that particular sentence is simply the fact that if you were going to estimate damage, or benefits, or any other change, whether it be positive or negative, it must be so estimated quantitatively for as much as possible in order to get a good assessment, but I would like to distinctly clarify -- make a distinction between overall effects and actual damage. Effect is just something that is apparent. Damage is something that is physiologically detrimental.

Q If you're a farmer like Wally McGraw --

A You mean Wally McRae?

Q McRae --out there, trying to see where you're going, your eyes are watering, you have bilateral conjunctivitis as a result of exposure to sulfur dioxide, that's not damage in your book, is it?

MR. PETERSON: I'll object to that on the grounds that it assumes facts not in evidence.

HEARINGS EXAMINER: Sustained.

MR. PETERSON: Improper cross-examination.

HEARINGS EXAMINER: If you want him to assume that somebody has his eyes watering, that's something else.

Q Why don't you assume that and then answer my question, Doctor?

A I would assume a person suffering under those kinds of conditions would certainly have a deletery effect.

Q Would you call it damage by your definition?

A Only if his eyes were affected to the degree that they could

not immediately recover after being taken out of that kind of a situation.

Q Well, assume he's out on the range for eight hours a day. Wouldn't that be a little tough on a guy to live in that environment?

A I find it a little bit tough to imagine that kind of environment.

Q You've never lived in an environment like that yourself, have you?

A I was born in Manhattan, in New York City, and I've lived in that environment for a number of years.

Q All things are relative, aren't they?

A I would be the first to agree with that. However, relativity does not necessarily make your eyes water.

Q Would you tell me what the distinct benefit is in the ecological sense to Wally McRae, who's going to be exposed to emissions of sulfur dioxide from the Colstrip generating plant?

A Right off the top of my head I cannot readily think of any distinct benefit or adverse effect that he would suffer.

Q Assuming the main grasses which thrive in the vicinity of Colstrip now are exposed to sufficient levels of sulfur dioxide concentration during their most sensitive period, what is the distinct benefit to the cattle that have to rely on that forage for grazing?

A I would like you to rephrase your question, please, in a way that I may understand it better.

Q If grasslands are depleted as a result of exposure to sulfur dioxide, is there any distinct benefit to be derived by cattle?

A If grasslands -- If grasslands were to be depleted, I could not see any distinct benefits to cattle, no, but that is not any kind of a reasonable assumption that I would make.
Q That's an assumption you wouldn't make?
A That is very definite.
Q Dr. Edmonds, you've never been involved in what has been called the CHESS study?
A No, I have not.
Q You don't consider yourself qualified as a medical doctor, do you, to make the statement that --
A As I have testified.
Q -- the Colstrip electrical generating facilites are not expected to produce significant effects upon humans.
A I have testified before that I am not a medical doctor nor would I presume to be able to make any qualified statement relative to those effects.
Q Did you ever make any study as to what concentrations of either hydrogen fluoride gas or sulfur dioxide it would take to wipe out a bee colony?
A Have I done any investigations?
Q Yes.
A No, I have not.
Q Have you even addressed that question in your evaluation of potential terrestrial impacts occasioned by the operation of Colstrip units 3 & 4?
A I have looked into the concentrations necessary to cause major effects, or effects, period, in major classifications of organisms, and have not run across specific references to the

one that you have just mentioned.

Q Bees?

A That's right.

Q Don't bees have a pretty good function in the environment?

A They do.

Q They help things grow, don't they?

A Well, I wouldn't say that they help things grow. I would say that they help to proliferate the natural environment by transference of pollen.

Q Well, in technical terms, that sort of helps you get started, right?

A No, in a scientific sense, if you want to distinguish between pollination and any other ecological or biological factor, that is something that is completely separate.

Q Have you ever studied what happens to the effectiveness of new crops in the absence of bees to assist in pollination?

A That depends on the particular crop that you're talking about. Bees would pollinate specific species and not pollinate others.

Q Alfalfa, for one.

A Okay.

Q Have you studied it?

A Bee pollination of alfalfa?

Q Right.

A No, I have not.

Q Cherries?

A No, I have not.

Q Doctor, you make the statement on page 18 that, "... careful literature review indicates that high humidity and soil

moisture are both required for maximum plant susceptibility to sulfur dioxide."

A That is correct.

Q What time of the year at Colstrip is the humidity the highest?

A I would say in the early spring.

Q That's the growing season, isn't it?

A That is one of the major growing seasons for a number of species, yes.

Q It certainly is for Western wheatgrass, Bluebunch grass, and Red threeawn, isn't it?

A Yes, it is.

Q What period of the year is the soil most moist at Colstrip?

A During that same period.

Q And in the phenology of plants, and especially those grasslands, they're most susceptible at that time of the year, aren't they?

A I would not say that, no.

Q You wouldn't?

A Not based on just humidity alone. You have to again make a distinction that in those experiments that have been made it has been generally demonstrated that an increased humidity or soil moisture has increased the susceptibility of plants; that is, in general, and there are a number of plants that have been used in experimental conditions to verify that fact. I would say that if the concentrations of SO_2 were anywhere in the area that would be a concentration to cause detriment to those particular plants, and if those concentrations were established around those plants for a sufficient

period of time, then they would be susceptible.

Q Doctor, you're giving me a lot of "if's". I understand you have to, because there's been no exposure to any of the existing grasslands at Colstrip to SO_2 over the growing season, yet, has there?

A I don't know what the relationship of that has to do with their sensitivity.

Q Well, wouldn't it be nice to know just what the effect would be on the grasses at Colstrip if they were exposed to SO_2 during the growing season before you make such an opinion?

A There have been studies made, fumigation experiments, on the grasses.

Q Oh, fumigation experiments?

A That's correct.

Q Where?

A Clyde Hill has done a number of these fumigation experiments.

Q At Colstrip?

A On similar species, the same species as at Colstrip.

Q Did A. Clyde Hill do that with Bluebunch grass?

A I don't recall right offhand. I don't believe so.

Q Western wheatgrass?

A I don't believe that particular species, either. If you would like to know what ones he did, I have outlined all of those species that he has done that work on in association with other authors who have also done similar work in the Colstrip report. The listing is right there for you to see.

Q Well, why don't you check your outline, Doctor, and see if he did Bluebunch wheatgrass.

A As I've indicated, I don't believe that he did.
Q And that's a species common at Colstrip, isn't it?
A All of the species at Colstrip have not been studied. All of the species in the world have not been studied.
Q Well, is it scientific in your estimation to prognosticate that there will be no damage, without even having had the benefits of fumigation experiments on that particular type of grass, or a track record like maybe exposure to those pollutants during the growing season?
A It is entirely reasonable to estimate, as I have done in this testimony, that it is not expected that adverse reactions will occur due to the operation of the plant, because of the very, very low level of effluents coming from that plant, the duration of those effluents over a period of time on vegetation, even those that have been identified as being most sensitive. Those levels are so far below those levels that would indeed be required to cause that kind of damage.
Q All right, Doctor, what level is required to damage Western wheatgrass?
A I don't know right off the top of my head.
Q What level is required to damage Bluebunch wheatgrass?
A Again --
Q What level is required to damage Bluebunch wheatgrass?
A I don't know.
Q You don't know any of these, do you?
A As I have indicated, the number of studies that have been done have not been done on all of the species in the world or on all of the species at Colstrip, but those studies that

have been done have indicated that the levels are nowhere near, anywhere reasonably near, those levels that would be at the Colstrip vicinity, or for the length of time.

Q Let's stop talking in generalities, Doctor. Tell me the three most predominant forms of grasslands in the Colstrip area, and you tell me their threshold level of exposure that will cause them damage, right now.

A That cannot be said. Knowing the predominant species there being ponderosa pine --

Q Is that a grass?

A All right, let's take one of the most sensitive grasses identified to date, and that would be Indian ricegrass; at a fumigation for two hours, a fumigation on a concentration of half a part per million of SO_2, you would end up with .2% damage. That is the most sensitive species that has been identified for that area.

Q That's Clyde Hill, isn't it?

A That is correct.

Q Clyde's working for Four Corners, isn't he?

A That is correct.

Q Where did he fumigate?

A In the Four Corners area.

Q What time of year?

A I don't recall right offhand. I believe that he's done it on several periods throughout the course of the year.

Q Did Clyde Hill fumigate during the sensitive phenological times in a plant's development?

A Clyde Hill has done experiments with the differences in

humidity in the soil to increase the possible susceptibility of those plants due to increase of humidity.

Q Well, I'm talking about the sensitive plant, Doctor. I want to know whether you can tell me, under oath now, whether or not Clyde Hill conducted those experiments during the most sensitive time in the phenology of that particular grass?

A I am not aware of that fact.

Q Incidentally, Doctor, there is a big difference, isn't there, between fumigation chamber experiments and that being out in the field?

A The major difference is that the concentration of the effluent is there at that concentration for the period of time of fumigation. The time of fumigation needed to cause those particular effects at that extremely high level was a duration of two continuous hours of fumigation.

Q You forgot about mentioning the lack of the drying effects of wind. Isn't that one thing that is missing in fumigation chamber experiments?

A That is correct.

HEARINGS EXAMINER: We will take a 10-minute recess.

(RECESS AT 3:07 P.M.)

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Following a brief recess, the hearing reconvened at 3:40 P.M. on January 29, 1976.

HEARINGS EXAMINER: You can proceed.

CONTINUATION OF EXAMINATION OF DR. PETER R. EDMONDS

Cross, by Department of Natural Resources and Conservation

By Mr. Sheridan (continuing):

Q Dr. Edmonds, would it surprise you to learn that in A. Clyde Hill's fumigation experiments, Dr. Hill fumigated on one site for two hours only with no replications and moved the fumigation site?

A What do you mean, he moved the fumigation site?

Q The spot that he was fumigating during his fumigation experiments.

A And went on to another site and conducted other experiments?

Q Right -- fumigation at another site.

A Yes.

Q Two hours' exposure, no replication.

A Well, he replicated his experiment on similar species at different sites.

Q Right, but you don't have a cumulative dose, do you?

A A 2-hour exposure is an acute period of time.

Q Well, I agree that's an acute period of time, but it really doesn't tell what the exposure would be over the long term during a growing season, does it?

A You mean as a measurement of chronic effects?

Q Right.

A His experiment was not conducted to measure chronic effects.

It was for acute responses.

Q That's right -- short, acute responses, not long term chronic response, right?

A That is correct.

Q You haven't made any studies on seedling growth around Colstrip for any of the ponderosa pine or limber pine, have you?

A I am aware of studies done on that subject. I myself have not performed such studies in the field.

Q Have you ever done any population stability studies in the field for ponderosa or limber pine?

A No, I have not.

Q Have you ever done any studies in the field over the long term to determine leaf retention?

A Again, the semantic problems of long term -- you're speaking as the term of my experimentation?

Q One year.

A Again, my experimentation of a period of one year or more?

Q Yes.

A No, I have not.

Q On page 20 you talk about "The Handbook of Effects Assessment, Vegetation Damage." Can you tell me in that handbook how many species in the plant kingdom are represented?

A I don't recall the exact number right offhand.

Q How many plants are there in the plant kingdom? Spermatophytes?

A Spermatophytes?

Q Yes.

A I don't recall the estimated number right offhand. Do you

mean as far as a global number is concerned?

Q Right.

A Or an identified species?

Q Right.

A I don't recall the specific number right offhand. It's somewhere probably in the nature of -- roughly, just making a guesstimate of from what I do recall, it would be somewhere around, oh, 50-55 --I'd say 50 to 60 thousand, something of that sort.

Q Do you know how many are in the handbook?

A As I indicated, I do not recall that number.

Q Do any of those that are in that handbook grow in eastern Montana around Colstrip?

A No, they do not.

Q Doctor, looking at page 21, first of all, you say on page 21, line 21, "Little sulfur dioxide soil sorption is expected to take place in the semi-arid Colstrip area." Now, isn't that inconsistent with what you say at lines 13-15, that "Although most soil sorption of atmospheric SO_2 increases acidity of the soil surface in industrial regions, this is not expected to be a problem in the Colstrip area because of the neutralizing effect of the basic (alkaline) soils present"?

A The neutralizing effect would be one component, but here I'm making reference to the overall precipitation in the area.

Q Well, soil sorption will occur, won't it?

A Some soil sorption will occur, yes.

Q During about a 3-month period, right?

A I indicated that little is expected to occur.

Q Is that little in terms of time?
A In time and amount.
Q What measurements have you made to determine soil sorption capability for SO_2 sorption in the soils at Colstrip?
A I personally have made none.
Q Can you relate the statement on page 20, line 20, that "Plant species in the Colstrip area are no more sensitive and in the large majority of cases extremely more resistant to sulfur dioxide than alfalfa and barley ..." to your comments on the "Handbook of Effects Assessment, Vegetation Damage"?
A Now, would you repeat just the very beginning of that question, please?
Q Can you relate as justification that handbook to that statement?
A Yes, I used that particular handbook for that statement, as well as references by Altman and Dittmer; also a reference by Barrett & Benedict support that statement.
Q Do they talk about Colstrip grasses?
A They don't talk specifically about the Colstrip grasses. What they do talk about is the relative sensitivity of some of the most sensitive species that have so far been identified.
Q And the Colstrip grasses are not addressed in their work, are they?
A That is correct. What they have used in their work, as I have indicated, are those species which are nationally recognized as being examples of the most sensitive species to SO_2.

Q Now, Doctor, on page 21, line 25, you say, "Chronic sulfur dioxide injury to plants results from sulfate accumulation in foliar tissues and resultant toxicity. Such toxicity produces leaf chlorosis and reduced photosynthetic efficiency proportional to the extent of injury." Have you talked to Dr. Leonard Weinestein regarding his data of fluoride pollution, where he lost 30% biomass without physical injury?

A No, I have not. I would have to, in order to make a judgment on that particular matter, know specifically what the criteria was that he had and what the specific species were, what it were subjected to, and how he could have possibly had that kind of damage without some observable effects.

Q You haven't talked to Dr. Weinestein on that?

A No, I have not.

Q Do you know Dr. Weinestein?

A I know of him.

Q At Boyce Thompson Institute?

A That is correct.

Q Doctor, what studies have you conducted regarding the sensitivity of white pine to SO_2?

A Personal studies I have not conducted; that is, studies in the field.

Q Where is white pine located in the United States?

A It depends on what species of white pine you're talking about.

Q Which white pine are you talking about?

A I'm talking here about the eastern white pine.

Q And you don't find eastern white pine in Colstrip, do you?

A No, you do not.

Q What's a limber pine?
A What is a limber pine?
Q Right. Do you find that in Colstrip?
A No, you do not.
Q You've never seen one there, right?
A I have not observed limber pine, as I have indicated before. I have personally not observed it east of Helena.
Q Going on to page 23, Doctor, Nitrogen Oxides, at line 11 you say, "Neither short nor long term exposures to expected nitrogen oxide concentrations from the Colstrip facilities are expected to produce significant effects in vegetation, wildlife, humans or domestic animals." What studies have you conducted other than literature searchs to determine the effects of nitrogen oxide upon vegetation?
A I have not personally conducted any studies in the field. That conclusion is based upon the levels that would be expected, the calculated levels, from the Colstrip plant, and those levels that have caused pollution -- or caused damage, rather -- in a polluted atmosphere. The levels are so fantastically different, thousands of times different, that I can see no relation.
Q You can see no relation in terms of injury or damage, right?
A That is correct.
Q And that's by your definition on page 16, right?
A That is by a formulation of a basis studying those particular cases where it has been identified in the literature.
Q Have you ever done any field work to determine the effects of nitrogen oxides on wildlife?

A No, I have not.
Q Humans?
A No. Here again, as you have pointed out throughout a good portion of this particular statement, the conclusions that I've come to are those conclusions which are based upon an evaluation of experts in the field that have conducted these types of studies, and I concur with their conclusions.
Q Well, Doctor, I'm here to find out what you know and what you can say from personal experience and research, not what other people tell you.
A What is in my statement is what I know, and that is based on recognized experts in the particular fields of each one of the subject categories.
Q Yes, and in several areas you've been unable to tell me who that is, too.

MR. PETERSON: Objection, argumentative.

A In a couple of areas I have stated that I do not recall.
Q And of course, whatever concentrations of average annual NO_2 would be present around the Colstrip site are calculations based upon information provided you by the Power Company?
A These are averages which have been calculated from those estimations put forth by exhibits in this particular hearing, and some of those contained in the facts and conclusions of law.
Q And you got that information, though, from the Power Company, didn't you?
A I received the basic copies, the actual copies of the facts and conclusions, as a normal occurrence in the procedure of

of this testimony.

Q And you understand, don't you, that all those figures are estimates?

A Yes. I fully understand that they are estimates, other than the fact that there are specific criteria, such as the burning of less than 1% sulfur coal, which would put a limit on how far these estimates can go.

Q You are not familiar, are you, Doctor, with the method used to determine the sulfur content of the coal or any reservations in that estimate?

A You mean as far as accuracy of that estimate is concerned?

Q Yes.

A I know that there are various methods for doing that and that methods that are widely recognized as being acceptable have been the ones that are utilized in these determinations.

Q On page 27 you make a statement, starting at line 1, "Susceptibility data obtained from fumigation experiments indicate that the lowest fluoride concentration required to cause slight injury to the ponderosa pine after 7 to 9 days of continuous exposure is at least 0.8 ppb." What data did you depend upon for that statement, Doctor?

A This statement has come from Committee on the Biological Effects of Atmospheric Pollutions that has been submitted specifically for fluorides by the National Academy of Science in Washington, D.C.

Q Do you know who funded the committee that prepared the chapter on fluorides?

A Who funded the committee? Is that the question you asked?

We're talking about dollars?

Q Yes.

A Again, I'm not really aware of those kinds of things.

Q Would it surprise you to know that most of the men on that committee that prepared the chapter on fluorides are consultants to the largest fluoride emitters in the United States, the aluminum industry?

A I was not specifically aware of that fact at that time, but I can't help but feel, from your particular comments and those comments you have made previously pertaining to SO_2, that there is no reason why there should be any difference whatsoever in the evaluation of these kinds of effluents, or how they act, or the fact that you would get damage if they were not done by someone associated with those kinds of people, or you would get damage if they were done by independent consultants. I don't really understand what the difference would be or what you are trying to imply by that kind of a statement.

Q You don't?

A No, I don't. I would like for you to explain that, if you would, please.

Q I could make a speech, Doctor, but it's not the proper time.

A I'm just looking for an explanation to interpret your questions.

Q Well, then, why, Doctor, haven't you come to see Dr. Gordon and look at his histological studies or his chemical analyses?

A I have read Dr. Gordon's papers thoroughly.

Q That's enough, right?

A I am familiar with the work that he has done and I am familiar with the objections to that work.

Q You prefer to speak to the objections and not to pursue the matter further to look at what you haven't taken the time or made the effort to go view, isn't that right?

A Based on the work done by recognized experts in the field, I concur --

Q I'm talking about --

A I'd like to finish my answer, if I may, please.

Q I'd like you to respond to my question, Doctor.

MR. PETERSON: May the witness finish the statement, Mr. Davis?

MR. DAVIS: What was the question that he thought he was answering? Do you recall that? Why don't you ask another question, and then you will be permitted to answer.

Q You haven't taken the time to go out to Missoula, have you, Doctor, and take a look at what's at the lab in the way of photographs, histological studies, or chemical analyses involving the effects of hydrogen fluoride upon conifers?

HEARINGS EXAMINER: Now you may answer and explain your answer, sir.

A I have taken the opportunity, yes, to request of Dr. Gordon all of the information that he has had available to him on several occasions, as I had indicated before, for the purpose of evaluating fully his studies. I have evaluated his studies based on the information available to me, made available through him or through other sources, as well as the information made available to me through the work of other recognized experts in the field, and I have come to the conclusion that

based on --

Q Doctor, do you --

A Pardon me?

Q Go ahead and finish.

A Based on the studies I have evaluated and the work that has been done by other recognized experts, the conclusion so stated in this testimony is my conclusion.

Q Now, would you answer my question?

A Would you repeat your question, please?

Q You have not taken the time, have you, Doctor, to come out to Missoula to look at the slides, the chemical analyses, the photographs that are part of the reports that Dr. Gordon has prepared?

A I have taken the time --

Q Have you come out to Missoula to look at them, Doctor? Yes or no? You can answer that simple question, can't you?

A May I answer the question in my own words, please?

Q Well, just give me a yes or no; then explain. Have you gone to Missoula, Doctor?

A I have not come to Missoula. I have taken the time to specifically request of Dr. Gordon, both in person and over the phone, for all of the available information that he would have that might benefit my analysis.

Q You haven't seen a single slide, have you?

A I have not been asked to have an opportunity to review a single slide in person, nor have I seen a particular slide other than those photographs which he has presented.

Q And you're aware of the presence of those slides, aren't you?

A Yes, I am. I am also aware of the problems associated with interpretation of those slides.
Q Good. What histological studies have you ever conducted, Doctor?
A As I indicated before, I am not a trained anatomist and I don't believe Dr. Gordon is, either, but I would not venture to look at a slide of that sort without specific training and come to a conclusion. I would rely on a recognized expert in anatomy for a conclusion based on that fact.
Q You're guessing about Dr. Gordon's qualifications, aren't you?
A As an anatomist? I don't believe that Dr. Gordon has a degree in anatomy.
Q Doctor, I am discussing with you whether or not you have any idea as to the ability, the training or the capability of Dr. Gordon to interpret histological slides.
A I am aware of the fact that --
Q I am not talking about degrees, Doctor. I am talking about abilities.
A I see. I am aware of the fact that Dr. Gordon has done some work in this area. I am aware that there are specified and publicly stated contradictions to that work, and I'm aware that there is some basis for those contradictions.
Q Do you know of any scientist in the State of Montana who has collected more vegetative samples, histological slides or chemical analyses for growing plants in the State of Montana than Dr. Gordon?
A As I've indicated before, there are many scientists in the State of Montana that have done considerable work in those

fields, and I think that I am not knowledgeable to the extent to be able to quantify the exact number of days or duration of any of those scientists as far as how much work they have done, except that their work has been extensive.

Q But you're just guessing, aren't you?

A Guessing about what? I haven't made any qualification whatsoever.

Q Whether or not Dr. Gordon has done more than anyone else in this state.

A As I indicated before, I would not like to venture a guess on that matter, and I would not like to state so.

Q Doctor, you've got Table 1 there on page 32? Do you have that in front of you?

A Yes.

Q Before we get to the table, let's go to line 9 on page 31. You say, "Projected particulate deposition rates for the area of maximum deposition 10 miles southeast of the Colstrip units." On whose property is that site located?

A Just a second here till I review this, if I may, please. (PAUSE) Okay. I am not aware as to the property owner in that specific area.

Q Is it somewhere near Wally McRae's property?

A I would imagine so. I know that he's right in that area.

Q Who did the calculations shown on Table 1?

A These were done by me.

Q By who?

A By me.

Q Oh, I'm sorry. Could you have made a mistake on beryllium

here?

A Pardon me?

Q Could you have made a mistake on beryllium?

A I can't say that I haven't. It might be possible. I'm not aware of the mistake in the numbers as I see them.

Q Is there any difference in the math you used between arsenic calculations and beryllium, particularly in determining the ratio of amount deposited in 40 years to the base line level in the top inch?

A These were based on the amount that would be contained in the coal, the estimated amount in the coal, based on the chemical properties of each one of these compounds and based on the percent emitted as stated by DNR Exhibit 123.

Q How did you determine that the correct assumption to make was that only 1/10th of the particulates that will impinge on each acre will be retained by vegetation each year?

A This is an estimate based on the amount of deposition, the amount of rainfall washing off, wind taking -- carrying this dust away from the vegetation. It is an estimate.

Q What field studies have you conducted in the Colstrip area to determine the validity of those assumptions?

A I think the assumptions are reasonable assumptions based on the nature of my calculations, where I have made these calculations based on 100% capacity emission rates.

Q What field studies have you made to determine the validity of the assumptions?

A As indicated before, specific field studies on this subject matter I have not made personally.

Q How did you make the determination of how much vegetation there is per acre?
A This was done by using a publication by Tucker, Miller and Pearson on the amounts of vegetation cover in this type of an area, percent cover of vegetation. It is equivalent to what I would expect in this area.
Q Did those authors work in Colstrip?
A Specifically in that area, no. This was an evaluation based on remote sensing done for short grass prairies in general.
Q Where?
A I believe it was Colorado, if I recall correctly.
Q So your assumption on the ground cover at Colstrip is based upon studies done in Colorado?
A No, not entirely. It is based upon the studies, but it is also based upon the data that was accumulated in evaluating what the percent cover would be for the Colstrip area.
Q What procedures were developed and utilized to develop the assumption of the extent of ground coverage per acre at Colstrip?
A These studies were done during the time of characterization of the vegetative types in the Colstrip area.
Q Who did them?
A These were done by Brian Sindelar.
Q How did he do it?
A He mapped the area, walked the area extensively, and looked for each vegetative type, measured it and mapped it; indicated in that report the relative ground cover for each particular type. Similar type of ground cover was used in the remote

sensing report by Tucker.

Q That doesn't involve Colstrip, does it?

A Tucker's report? That was a general report for the short grass prairie. Colstrip would come into that area. It would be typical for that area.

Q The short grass prairie?

A Yes.

Q What's the percent bare ground at Colstrip?

A I don't recall that number right offhand, the average number.

Q Will you review beryllium on your Table 1 and tell me whether or not the ratio of the amount deposited at 40 years to the baseline level in top inch should be .3 rather than .003?

A That is possible; yes. To definitely confirm that fact I would have to run through the calculations again, but it is entirely possible.

Q Doctor, going into the section on arsenic on page 33, you make the comment that "Horses and cattle can ingest approximately 20 to 30 grains of arsenic daily for many years with no apparent ill effects; this ingestion rate corresponds to approximately 1,000 ppm. daily." How much does a horse or cow eat grazing a day?

A Should I say that depends on how hungry he is?

Q Well, what studies have you done, Doctor?

A This particular reference was taken from Lillie; it was entitled "Air Pollution Effects Affecting the Performance of Domestic Animals." This was based on his studies.

Q Assuming you have .03 ppm. arsenic in vegetation, how many

pounds would an animal have to eat daily in order to consume 1,000 parts per million?

A I can't run through that mental calculation right off the top of my head.

Q About 4½ pounds of food a day, isn't it?

A I'll have to take your word for that.

Q Going on to page 35, Doctor, you make a statement at the bottom of the page that, "Cattle, the domestic animal most sensitive to fluoride, can safely ingest forage containing up to 35 ppm." I take it, Doctor, you're familiar with the work of F. LeGarde Shupe?

A As I recall, yes, I have reviewed some of his articles.

Q Did you know that his articles say that damage to domestic animals such as cows can be caused by ingestion of forage containing 29 ppm?

A There are ranges about this average figure, and that comes within the range -- 29 to 35. This is the middle of the range, and it depends upon what particular species you're talking about. This is the normal number that is representative of that range, and the number that is generally accepted.

Q By everything except the cattle?

A Ill effects at these numbers as has been reported by Lillie in that same reference that I have given you has indicated that these are not deleterious effects.

Q To a range cow?

A He indicated the most sensitive organism in this particular area.

Q Do you know what the effect is at consumption of 29 ppm on a

dairy animal?
A Not right offhand, no.
Q You say, "Most animals are better able to tolerate fluorides in greater quantities than cattle." What authority do you have for that, Doctor?
A The same authority.
Q What authority is that?
A Lillie.
Q Lillie? When was that study done?
A That study, I believe, was done in 1972.
Q What's the difference in the digestive system between cows and antelope, white tail or mule tail deer?
A A cow has a multiple digestive system which retains and digests further the forage that he has eaten.
Q It's a ruminant, right?
A Yes.
Q Isn't an antelope the same?
A I believe it is, yes.
Q How much fluoride ion in parts per million is retained in a cow as opposed to how much is excreted?
A I don't have those figures right at my fingertips.
Q It's true that animals that excrete less retain more fluoride, don't they?
A That is true.
Q Where does the fluoride go?
A The fluoride is accumulated in the bone tissue of the organism.
Q About 99% of the fluoride ingested in consumed in the bone tissue, isn't it?

A There are varying amounts, depending on the organism involved.
Q Well, let's take dairy cattle.
A Cattle, as I've indicated, is one of the most sensitive of organisms. I would expect that high a range.
Q That goes for beef cattle, too, doesn't it?
A Yes, it does. That's why specific studies of this sort have been done, and that's why an average of 35 ppm. has been identified as being that level which is safe.
Q Do you know who funded the study that says 35 ppm?
A No, I have no idea who funded the study?
Q Would it surprise you that it was the Aluminum Association of America?
A After the other testimony that has come out today, or the questions that you have asked me in that testimony, I again would not be a bit surprised, but I again question why you have raised such an issue and what relevance it has to this testimony.
Q I just want to know if you know, Doctor.
A No, as I indicated before, I am not really concerned all that much about who funds what. I am interested in the scientific data that has been accumulated, the importance of that data, and whether that data is really representative of the situation at Colstrip. My conclusions based in this testimony indicate everything that I have so stated before. I do not find that there will be an deleterious effects.
Q And you're not uncomfortable as a bioecologist testifying what the effects of SO_2, HF, O_3, NO_x would be on humans, although you're not a medical doctor; or on animals, although

you're not a veterinary toxicologist, are you?

A You've asked me two questions.

Q Well, you can answer both of them, can't you?

A Animals and humans are specifically less susceptible to concentrations that have been known to cause damage to plants. Every indication that I have from the studies that I have summarized, also from the physical description of the operation of the Colstrip units, indicate that the levels coming out there will not even be injurious to plants, so I base that upon the conclusion that it would not be injurious to humans or lower forms of animal life.

Q Looking at your statement as a whole, Doctor, it sort of surprises me, but really it doesn't, I guess -- you can't conceive, can you, of any damage out of Colstrip?

MR. PETERSON: I'll move to strike the comments of counsel other than the question.

HEARINGS EXAMINER: They'll be stricken, other than the question.

A Given the operating parameters of Colstrip, I have concluded that it is not reasonable to assume, under any circumstances, that there would be actual damage occurring over the long term or the short from the operation of Colstrip units 1 through 4.

Q And of course, Doctor, the basis you have asserted, particularly with respect to nitrogenous fertilizer, nitric acids, and sulfurs, are minority viewpoints, aren't they?

A I would not say that. No. I would not say that it is a majority viewpoint, either. I haven't done an analysis of

who's in the majority and who's in the minority.

Q You know doggone well that Dr. Frohliger's in the minority, don't you?

A No, I do not.

Q Do you have another written work that supports him?

A I really question the validity of the two different reports that you have, one done by DeNardo and his complete methodology as associated with that done for science. It seems reasonable, just as an example, and using him as an example, if an author of that caliber were to publish a paper in the Journal of the caliber of Science, that would have to necessarily be reviewed by people knowledgeable in the area and offer specific comments for the development of that paper, that the methodology that he employed would have been severely scrutizined and would have been reasonable to use that particular methodology.

Q Doctor, can you name me one other publication that supports Dr. Frohliger?

A Right off the top of my head I can't site another one, other than what I have already stated in my testimony.

Q Doctor, on page 38, shouldn't that figure on line 26 be 10^5 pounds rather than tons? Just briefly glancing at it it looks like maybe -- it looks to me like you're off by a factor of 2,000.

A Where are you again, please?

Q Page 38, line 26.

A Now, would you repeat your question, please?

Q Aren't you off in your calculation there?

A On the number "2 x 10^5"?

Q Shouldn't it be "2 x 10^5 pounds" rather tahn "2 x 10^5 tons"?

A Yes. I'll accept that correction very readily.

Q Now, Doctor, what's the danger of ingestion of lead?

A Lead is toxic to animals and to plants.

Q It will kill them, won't it?

A If enough lead is ingested, if the proper concentration is ingested, yes, it will kill them.

Q Have you ever made any studies determining the effects of lead particulate emissions from coal-fired generating facilities?

A Specific studies that I have conducted in the field, no.

Q Is the same true for mercury?

A That is correct.

Q What is the danger of mercury poisoning?

A Again, mercury poisoning can be lethal if a high enough concentration is reached.

Q And it accumulates in the human body, doesn't it?

A Yes, it does.

Q Specifically in the brain, right?

A Right.

Q It causes iddy-iddy disease, doesn't it?

A That is one symptom. I wouldn't call it a disease.

MR. SHERIDAN: I have nothing further.

HEARINGS EXAMINER: Mr. Meloy.

Cross, by NorthernCheyenne Tribe, Inc.

By Mr. Meloy:

Q Dr. Edmonds, how old are you?
A 35 years old.
Q You were hired to assess the potential bioecological effects which might result from the operation of Colstrip, is that right?
A I conducted a thorough analysis on possible bioecological effects that might be operating in Colstrip.
Q Bioecological effects contemplates all living things that might exist in the area?
A Those effects that would have some type of effect on the ecology, the bioecology of the area, yes.
Q In order to make that kind of an assessment you needed to know the makeup of the ecosystem before you did the study in order to project what might happen to that ecosystem should the plants be built?
A That is correct.
Q I think you told Mr. Sheridan that you yourself had spent 30 days, is that right?
A Approximately, yes.
Q In the vicinity of Colstrip, but that since you are not a field man, most of your conclusions are based on other people's studies, is that a correct statement?
A They are based on other people's studies, other people which I have employed to do studies there, or asked to conduct studies there, yes.
Q And other studies that happen to have been done that you picked up, right?
A That is correct.

Q Now, among the various ecological factors that exist at Colstrip, one of the most important, is it not, is to know the prevailing -- what the prevailing winds are doing?
A You mean their direction?
Q Yes.
A Yes.
Q What are the prevailing winds doing in the Colstrip area?
A The prevailing winds are to the south-southwest.
Q Do you know where the Northern Cheyenne Reservation is?
A Yes, I do.
Q Where is it in relationship to the proposed site?
A I'd say it's just about due south of the proposed site, perhaps a little bit southeast -- I'm sorry, southwest.
Q All right.
A Before that, did I say the prevailing winds were south-southwest?
Q Yes.
A I meant south-southeast.
Q You meant south-southeast?
A That is correct.
Q And you think that the Northern Cheyenne Reservation is south-southwest?
A Yes. It is, as I recall it from looking on the map.
Q Have you visited the Northern Cheyenne Reservation?
A Yes, I've been down there.
Q Oh, you did?
A I've been down to Lame Deer.
Q Oh, you were in Lame Deer?

A Yes.
Q Is it important to know, in addition to the prevailing air currents, the variations in terrain in the ecosystem?
A Yes, it is.
Q What can you tell us about the most radical change in elevation in the Colstrip area, the most significant change in the terrain in the area of the proposed plants?
A Well, when you say the Colstrip area, are you speaking to the site itself, or --
Q In that area which you studied determining the bioecological effects of the impact of the plant.
A Well, the terrain itself is a mixture of rolling hills and sharp abutments, cliffs, some small mountainous areas to the south.
Q Do you know whether those moutainous areas occur on the Northern Cheyenne Reservation, the mountainous areas you spoke of?
A Yes, they do.
Q Did you visit any of those mountainous areas?
A I have been in their vicinity.
Q Did you visit the mountainous areas?
A You mean did I walk up a mountain?
Q Yes.
A No. I have driven a few of them.
Q Did you instruct anyone to walk up into the mountainous areas?
A No, I did not.
Q Did any of the reports that you looked at study the mountainous areas?

A Not as I recall. You're talking now about the specific one on the Northern Cheyenne Reservation?

Q Yes.

A Not as I recall, no.

Q Can you tell me what kind of vegetation exists in that area?

A From my own limited observations, it would be -- the predominant vegetation type would be ponderosa pine.

Q Is it important to know what species might exist in the area of the proposed site?

A Yes, it is.

Q And that's because certain kinds of vegetation are more sensitive than other kinds?

A That is correct.

Q Is it important to know how close the vegetation, be it sensitive or resistant, how close that vegetation is to the source of the effluents?

A Yes, it is.

Q Do you know how much timber is on the Northern Cheyenne Reservation?

A I would not be able to put a precise number on that, no.

Q Do you know what the predominant species of that timber is?

A Ponderosa pine.

Q Do you know anything about the carrying capacity of the pine forest on the Northern Cheyenne Reservation as opposed to, for example, the Custer National Forest?

A I would believe it would be somewhat number, but the exact number I don't immediately recall.

Q How do you know that it's that much lower?

A I said somewhat lower.
Q How do you know that?
A Only through conversations that I have had with some of the rangers.
Q With whom?
A Some of the forest rangers.
Q Forest rangers?
A That is correct.
Q On the NorthernCheyenne Reservation?
A No.
Q Well, I want to know --
A Out of Ashland.
Q All right. I want to know, then the forest rangers on the Custer National Forest told you that their carrying capacity was higher than the forest on the Northern Cheyenne Reservation, is that right?
A I do not specifically recall that they mentioned it exactly that way, no .
Q How do you know, then, that the carrying capacity on, for example, the Custer National Forest, is greater than the carrying capacity of the Cheyennes' forest?
A I am aware that the forest stand at Custer National Forest is a stand that is considered to be a fairly isolated stand, one that is quite vigorous and that other stands around it, not specifically the one on the Northern Cheyenne, but those other stands around it do not enjoy that same quality of growing conditions.
Q But you don't know whether those lower carrying capacity

forests are on the Northern Cheyenne -- it's possible that there may be --

A As I indicated, I believe that they are somewhat lower, but that again is from inference.

Q Who did you talk to? What is the name of the ranger that you talked to?

A His name was Mr. McGloughlin; and also Mr. Pearson.

HEARINGS EXAMINER: Just for the record, when you say "carrying capacity," you're not referring to livestock, you're referring to trees?

MR. MELOY: Mr. Davis, I'm going to get to livestock, yes, but right now I'm specifically referring to trees.

HEARINGS EXAMINER: Thank you.

Q Do you know what -- how important timber is as an economic base for the Northern Cheyenne?

A I know that it is an important base for them.

Q And you say that the ponderosa pine are the most susceptible of the species, tree species, in that area to effluent gases?

A Ponderosa pine is classified as having intermediate sensitivity to SO_2 specifically. It would be quite sensitive, for example, to fluorides, and it is -- well, for example, with SO_2 it would take, according to Clyde Hill's fumigation studies, approximately 10 ppm. for the first noticeable damage to a ponderosa pine.

Q Where did you get that data?

A That is from Dr. Clyde Hill's studies, fumigation studies -- that's the fumigation period of SO_2 at that 10 ppm. concentration for a period of 2 hours.

Q But isn't it important to know the various, as you told us earlier -- the variables which may exist in a given area before you can make any predictions about what might happen in terms of accumulations of poisons?
A Yes.
Q But you really don't know very much about the Northern Cheyenne Reservation in terms of terrain, except that it is higher there?
A I know that in that particular area it's quite mountainous. I'm not aware of the fact that all of that land in there is mountainous, but there are some mountains in that area.
Q The land with the timber on it is mountainous?
A Yes, it is.
Q Okay. Now, the taller your stack is, if you've got completely flat grounds the chances of poisons accumulating at any point are fairly small, if you've got flat ground, right?
A That all depends on the height of the stack and the wind dispersion characteristics.
Q Well, is there a greater chance of accumulation at a higher point on the ground at the same location from the stack as a lower place on the ground? I'm sorry, at a lower altitude?
A That would depend on the dispersion characteristics of the area. That can not be definitely said, in answer to your question.
Q Well, I'm talking in terms of probabilities here, and I'm willing to --
A Well, it's not as simple as that, because there are many factors that come into play, and that is just one of them.

Q You say that you've got prevailing southwesterly winds -- southeasterly winds, and there is an elevation point which is 1,000 feet. As compared with the same circumstance, prevailing southeasterly winds, and an altitude of ground at 2,500 feet, is it not more likely to have accumulations at the higher point as compared with the lower point?

A At that particular distance, taking the two distances to be equivalent, I would say in general, not considering any of the other characteristics that would have to come into play, that they would be somewhat greater, yes.

Q Do you know how high the stack is at Colstrip -- how high it is proposed to be?

A I believe it's proposed to be 525 feet.

Q Do you know how high the elevation is at the highest point in the southeasterly vicinity of that stack?

A You would have to include in that analysis the overall distance to that point of elevation.

Q Okay.

A Allowing for adequate dispersion, the distance you're referring to is considerably -- a considerable distance away, a distance that would have had a considerable amount of dispersion of those effluents resulting from the stack.

Q But the dispersion -- regardless of the dispersion, the molecules of gas somehow have to hit the ground?

A I suppose eventually they're going to settle down somewhere in some form, unless they're tied up atmospherically in some other form.

Q Okay, and that's likely to be a higher point closer to the

stack than a lower point?

A Not necessarily so. That depends on the distance again and the dispersion characteristics of the wind.. It could bypass such an area. That's entirely possible.

Q All right, let's reduce this hypothetical to reality, in the area of Colstrip. Same question.

A Well, the area that you're talking about is approximately 30 miles away from the Colstrip plant, and at that distance away the amount of, let's say, SO_2, for example, would be such an extremely low concentration that I cannot see how the effects of those kinds of concentrations would be deleterious to that area.

Q But you didn't study that area, sir. How can you say that?

A I said I did not perform any field studies in that area. I have looked at that area. I have studied where it is in relationship to the plant. I have studied the relationship of wind direction, which is not in the direction of that area, and I have studied the concentrations coming from that plant that may be dispersed throughout that area.

Q Would it surprise you to learn that Badger Peak, which is the highest point in the surrounding vicinity of Colstrip, is approximately 18 miles from the propsoed site?

A No.

Q It wouldn't surprise you? Would it surprise you if I told you that was in a southeasterly direction?

A No, it wouldn't surprise me.

Q And you still would say that the effect on the vegetation from accumulations is going to be, in your words, negligible?

A Well, when I made that prior statement I was talking about the Northern Cheyenne Indian Reservation, and the elevations at that point.
Q Badger Peak is not on the Northern Cheyenne Reservation?
A I don't know whether it is or not.
Q But if it's 18 miles in a southeasterly direction from Colstrip, you probably would have known about that, right?
A I would have looked at it relative to the dispersion characteristics of the effluents. My conclusion is that at a distance of 18 miles, as well as a distance of 15 miles or 10 miles, that the effect would not be deleterious.
Q But how can you say that if you have never studied that area?
A I have studied the area, as I have indicated before, for location of ponderosa pine, for the ridges, where they are located, wind direction, concentration of effluents that would be reaching that area.
Q You've studied the area and you still say that Badger Peak is 30 miles away from --
A No, I never did say it was 30 miles away.
Q Well, I asked you what the highest point of elevation was and you said you thought it was about 30 miles away before I told you that Badger Peak was only 18 miles away.
A I indicated that the area of the Northern Cheyenne Reservation where you would have ponderosa pine is a mountainous area approximately 30 miles away.
Q Badger Peak is not a mountainous area?
A Yes, it is.
Q Does it have ponderosa pine?

A Yes, it does.
Q If it were important for the Northern Cheyenne -- excuse me, I'll back up a second. You told me that you didn't know how important the timber on the Northern Cheyenne Reservation was to its economy.
A No, I said that I thought that it was important.
Q Was important?
A Yes.
Q You didn't know, you just think that it is?
A I know that that is a major component of their economy.
Q Do you know what percentage?
A No, I don't know the numbers associated with it.
Q How much would it cost the Northern Cheyenne, assuming the plants were built and fired up, say, 8-10 years from now, to determine the effects of the gaseous effluents on its timber? Does Westinghouse do that kind of work?
A Yes, they do.
Q How much would you charge to do that?
A I would not know until I had a chance to develop a complete work scope for that kind of a program.
Q Do you have a ball park figure on 130,000 acres of timber?
A Again, it would depend on the specific work scope and the type of experimentation that would be done, the length of time, duration of the experiment, the specific work scope; and I would not put a dollar value on it. As I've indicated many times before, I do not get involved with monetary estimates.
Q You do do that type of work, though, do you not?

A I do the scientific work associated with it, yes.
Q Do you know what type of business is most important to the Northern Cheyenne Tribe, economically?
A Not as I recall.
Q Would it surprise you to know that grazing, the cattle industry, is probably the most significant?
A No, it wouldn't surprise me in the least.
Q Do you know how much land is in grazing on the Northern Cheyenne Reservation?
A No, I do not.
Q Do you know the carrying capacity in cows per acre of that land?
A No, I do not specifically know it.
Q Do you know whether it's greater or less than the lands north of the Cheyenne Reservation?
A Specifically, I do not know whether it's greater or less.
Q Can you name species of grass which exist on the Northern Cheyenne Reservation?
A Not having been there to do a precise and onsite study for any specific area within that, no, I would not venture a guess as to what those species might be.
Q You didn't read a report that told you how much and what kinds of grasses existed on the Northern Cheyenne Reservation, and where?
A I don't recall reading one, no.
Q Your statement that the bioecological effects on the Northern Cheyenne from the four proposed Colstrip generating units is not significant, is that right?

A The statement that I made was in reference to the operational effects of the plants, and on the basis of my evaluation for the operational aspects of the plants, and the problems or concerns that may arise from that operation, I have come to the evaluation that those effects would not be seen at a distance that far from the plant.

Q But you told me at the outset that it's important in determining the bioecological effects to know what kind of vegetation exists, because some are more sensitive than others.

A You're assuming that there would be effects there. I'm concluding, on the basis of the study around the Colstrip immediate area that there would not be.

Q Well, I am not assuming anything. I'm not the person who --

A I have done the study and I have come to the conclusion that there would not be.

Q And you can't tell me from the results of your study what kinds of vegetation and where that vegetation exists on the Northern Cheyenne Reservation in terms of grasses.

A As I indicated to you, I have not done definitive studies in that particular area. The studies, as I have described before, have radiated out from the central core where the physical location of the Colstrip plant would be, and as they have radiated out, they have become less definitive, the immediate area around the Colstrip plant being that area which I considered to be most important, because that is where the effects might show up.

Q How far out is that, within the radius?

A The entire radius that I studied was a radius of approximately

30 miles from the plant.

Q Do you know where the boundary of the Northern Cheyenne Reservation is from the proposed plant?

A It is within that 30 miles.

Q And you don't know what the grasses are that exist on that area?

A As I said, the studies that I have done have become less definitive as they have increased in distance from the plant, because of the factors so stated.

Q What concentrations did you or any of the people who work for you or any of the studies that you read -- what concentrations did they predict, or you predict, for sulfur oxide, sulfur dioxide, NO_x at 15 miles from the plant?

A I have considered the maximum concentrations on long term and short term bases that would be found in the findings of fact and conclusions of law.

Q The findings of fact and conclusions of law will tell us what the concentrations are at 15 miles of those elements?

A As I have indicated, those are the maximum and long and short term concentrations.

Q I didn't ask you that, sir. I asked you what your predictions told you about the concentration of those compounds at 15 miles?

A My predictions have told me that if I were to double those levels and put them at that concentration at those 15 miles distances, that there would be no ill effects.

Q What was the number that you doubled?

A The long term number of 5/10,000 of a ppm of SO_2, as an example,

a ridiculously low number.

Q How much lower is that that what's occurring around the Corette plant, sulfur dioxide?

A I don't recall right offhand what the average concentrations are around the Corette plant.

Q Is it lower?

A I don't recall right offhand, as I have indicated, what the concentrations are around the Corette plant.

Q You did study the Corette plant, did you not?

A Yes, I did.

Q You just can't remember?

A That's right. I don't recall right offhand, as I have indicated.

Q You can't recall whether they're higher or lower?

A I'm not going to make an estimation just based on guesstimations.

Q We wouldn't want you to do that. Do you determine for other people around the country the effects -- you -- I'm referring to you or your office -- the effects of gaseous effluents on grazing lands? Would you do that kind of job?

A Yes.

Q Would you be willing to give me a number of how much it would cost the Northern Cheyenne to determine 10 years from now if the plants are built what the effects of those plants are on their grazing lands?

A I would defer to the previous statement that I have made, simply the fact that I do not personally get involved with monetary issues.

Q Are milk cows more susceptible to gaseous emissions than beef cows?
A Just as a broad, general statement, yes, I would say offhand; yes.
Q Do you know how many milk cows there are around the Northern Cheyenne Reservation?
A No, I do not.
Q Do you know how many beef cattle there are?
A No, I do not.
Q Do you know how many deer?
A No.
Q Do you know that the Northern Cheyennes don't have a hunting season and that they rely on deer for sustenance?
A No, I did not know that.
Q When you considered the impact of the proposed plants on the bioecosystem --
A The ecosystem is one specific entity. Bioecology is the study of the biotic components of that ecosystem.
Q Okay, does that include deer?
A Deer would be one of the components of the ecosystem.
Q Did you study the effects of the proposed plant on deer in the area?
A I studied the effects of the proposed projects on grazing animals.
Q Does that include deer?
A I don't recall right offhand whether I have a specific reference for deer or what particular kind.
Q Does it make a difference?

A Yes, indeed. Different species are more susceptible. That's why I took the maximum most sensitive type of species and included the 35 ppm. for fluorides, for example, for grazing cattle.

Q You're telling me, then, that the species that you looked at was more susceptible than deer?

A That is correct -- a more sensitive species, generally considered to be more sensitive; generally considered to be the most sensitive.

Q Cattle you say?

A That's right.

Q Are more sensitive than deer?

A That's right.

Q They've got the same kind of stomach apparatus, don't they?

A They're different animals.

Q They have the same type of digestive system, don't they?

A A similar type, rudimentary type.

Q Why are beef cattle more susceptible than deer?

A Because their uptake capacity is greater than deer.

Q They eat more?

A Physiological uptake; not the fact that they eat more.

Q They're smaller and they need more water?

A Mice are smaller, too, and they eat a lot less, but they uptake a lot less, also.

Q Do mice have the same kind of digestive system as a cow?

A Certainly not. What I'm saying is that there is no real relationship as far as size and amount ingested is concerned. Tbe relationship comes from percentage uptake that is specific

to the organism.

Q What is the basis upon which you predict that cows are more susceptible than mice in terms of the effects of fluorides?

A It has been determined for the effects of fluorides that cattle are the most sensitive organism.

Q How do you know that? What study did you use -- you told me a moment ago that cattle are more sensitive than mice.

A That's right.

Q What study are you referring to that told you that?

A As far as overall uptake is concerned, percentage of uptake, there have been studies done for mice, for example, on the Colstrip site itself, for the fluoride content of mice.

Q Who did the studies?

A Munshower, I believe, is one of the people. Sindelar, I believe, might have been associated with that.

Q On the susceptibility of mice to fluorides?

A No, on the content uptake -- the content of fluorides.

Q I'm asking whether you can tell me a study which is the basis of your statement that cattle are more susceptible to fluorides than mice.

A The basis for that statement is that it is generally recognized that cattle are the most sensitive species to fluorides.

Q If it's generally recognized then you shouldn't have any problem giving me the name of the person who has compared the two.

A Well, it would be the same study that I referenced before.

Q Which one was that?

A I don't recall right offhand what the name of it was. I can

look it up.

Q Did Lillie work with mice?

A Pardon me?

Q Did Lillie work with mice?

A I don't know whether he worked with mice or not. I don't recall seeing any work that he has done for mice.

Q Were you going to get out the study for me?

A Lillie is the study I was referring to.

Q But you don't know whether he worked with mice?

A As I indicated, I don't recall that he did. I don't believe that he did work with mice.

Q Are you familiar with baneberry?

A No, I'm not.

Q You're not? Then you can't tell me where it occurs in the area of Colstrip, or even if it does?

A That is correct.

Q Did you know that the Northern Cheyenne use baneberry as the spiritual representative of their Great Medicine Man, and that thus baneberry is a very, very important blessing for the Cheyenne?

A No, I did not know that.

Q Have you ever heard of the Plains cottonwood?

A Yes.

Q How about Green ash?

A Yes.

Q How about Quaking aspen?

A Yes.

Q Do all three of those species of trees exist in the area to be

impacted?

A Yes, they do.

Q Did you know that those species of trees are very important to Cheyennes for their Sun Dance?

A No, I did not. I do know, however, that those trees are not what you would consider species that are susceptible to -- or considered to be sensitive to SO_2 pollution.

Q From whence did you get that information? What study?

A I don't recall right offhand the specific study for that. This comes from general knowledge.

Q How about the juniper? The Rocky Mountain juniper?

A That does not have a -- junipers are not sensitive.

Q Not sensitive?

A They are not considered sensitive to SO_2.

Q Did you look at Dr. Hill's studies on the sensitivity of juniper?

A I don't recall a specific study that he has done on juniper, no.

Q Did you look at his studies on the effects on ponderosa?

A Yes, I did.

Q You don't remember him making any kind of a conclusion or study comparing the susceptibility of ponderosa with the susceptibility of juniper?

A I don't recall a specific study that was oriented for that particular purpose, where he had those two species and compared them. I know that he has done work with juniper. I know that he has found juniper to be sensitive, again with fumigation studies for a period of 2 hours, to approximately 6 ppm.

Q To be sensitive? Didn't you tell me that they weren't very sensitive?

A They are not considered to be a sensitive species.
Q What are they considered to be?
A Relative in range of sensitive, intermediate, and resistant.
Q Let's talk about relative to ponderosa, because you have --
A The ponderosa pine is not considered to be a sensitive species, either.
Q It's not considered to be a sensitive species?
A No, it's not. It's considered to be intermediate --
Q Didn't you tell me it's the most sensitive species of any in the area?
A I told you that, that is correct, but that doesn't mean that it is considered in general to be a sensitive species. I just said it would be the first one, probably, affected, because it has the lowest threshold level of any of the species in the area.
Q Would you be surprised if I told you that Dr. Hill found that juniper were much more sensitive than ponderosa?
A Well, as I've indicated to you, the level of sensitivity for the Rocky Mountain juniper, for example, is approximately 6 parts per thousand. That would be the threshold level, and that is lower than ponderosa pine at 10 parts per thousand, but when I was making that reference before, I was in reference to the immediate area around Colstrip where juniper are not growing.
Q Juniper are not growing south-southeast of the proposed plant?
A Yes, they do, but in the immediate area of Colstrip, the Colstrip site, in that direction I have not found juniper.
Q Would you be surprised if I told you that on the basis of

Dr. Hill's fumigation tests he found that with regard to ponderosa pine he would expect the 1% damage at 10 ppm, and he found with regard to Rocky Mountain juniper that to be 25% damage at 10 ppm?

A That's correct, at 10 ppm., yes. As I've indicated, it is a more sensitive species.

Q Juniper is more sensitive than ponderosa, you're telling me?

A I've told you that all along. I said ponderosa pine is sensitive at 6 parts per million, and that ponderosa pine is sensitive at 10 parts per million. (sic) Juniper, then, is much more sensitive.

Q I thought you told me at the outset that ponderosa was the most sensitive species in the area.

A As I've already indicated to you, I said that ponderosa pine is the most sensitive species in the immediate area around Colstrip, on what is considered to be the Colstrip site.

Q And there ain't no juniper there, is that right?

A I said that I have not observed any in the immediate area.

Q In the immediate area meaning how far?

A On the Colstrip site itself.

Q Oh, right on the site, right below the 525 foot stack?

A No, there are no juniper there, or ponderosa pine. Again, let me emphasize the fact that these levels of SO_2 that we are referring to now, after a full 2 hours of continuous fumigation, are nowhere near those levels that would be associated with the operation of the Colstrip plants. They are extremely high levels.

Q It seems to me that you told me there were many variables

to consider.

A That is true.

Q And it also seems to me that you told me that you didn't know very much about the variables on the Northern Cheyenne Reservation.

A I have indicated to you that through an analysis of the effects from the plant I would not expect to find any effects that distance from the plant.

Q What distance?

A A distance of your 18 miles, or even 10 miles, much less 30.

Q Are you familiar with prairie sage?

A Yes, I am.

Q Can you tell me where it occurred on the Northern Cheyenne Reservation?

A No, I cannot.

Q Do you know that prairie sage is used in almost every one of the Northern Cheyennes' ceremonies?

A I was not aware of that fact.

Q Are you familiar with kinnikinick?

A Not that particular name, no.

Q How about the name"arcpostaphylos"? A-R-C-P-O-S-T-A-P-H-Y-L-O-S.

A I'll have to remember that name for someday when I become inebriated by the exuberance of my own preposity, but right at the present time I'm not familiar with it, no.

Q How about dogwood?

A Are you speaking of the genus cornus -- dogwood? Yes.

Q You are familiar with that?

A Yes.

Q Do you know where that occurs on the Northern Cheyenne Reservation?
A No, I do not.
Q Do you know that the Northern Cheyenne use both kinnikinick and dogwood to smoke in all of their ceremonies, and also they chew the inner bark of the dogwood?
A I was not aware of that fact, no.
MR. MELOY: Mr. Davis, were you aware of that?
HEARINGS EXAMINER: No, but that's an alternate source. I'll keep it in mind.
Q Would you expect any of the plants that I have just mentioned to you to exist on the Northern Cheyenne Reservation?
A Would I expect that they would occur there?
Q Yes.
A Yes, it would seem reasonable that they do.
Q And because of the preceding number of questions on those plants, you wouldn't be surprised to learn that everyone of those were absolutely critical to the religious ceremonies of the Northern Cheyenne, and without those particular plants these ceremonies would not be carried out?
A I've gotten that impression from the statements that you have made, yes.
Q You would also do studies for the Northern Cheyenne to determine the effects of those plants after they have been built upon that vegetation that I just listed for you?
A Would you repeat the very first part of your statement, please?
Q Your firm would do those kinds of studies, but again you wouldn't speculate as to how much it would cost the Cheyennes?

A I would much prefer to do a baseline assessment at the present time in that area, and then continue on the studies to determine what the --

Q The baseline study which you haven't done now, right?

A A baseline study to determine whether there is any significant difference, but I would tend at the present time to decline being specifically associated with additional studies in that area, because as a basis for my conclusions for this testimony I would not reasonably expect to find any effects in those areas due to the operation of the Colstrip plants.

Q But you really don't know that, do you?

A I think it's an entirely reasonable assertion to make, based on the conclusions brought forth in my testimony.

Q Well, your testimoney, doesn't, nor does your cross-examination, tell me that you even know what kinds of species exist on the Northern Cheyenne.

A The basis of my testimony, and the basis of my comments here, indicate that since I do not expect any effect in that area that I have not made an assessment as to what the effects may be on. I do not expect that the area will be impacted.

MR. MELOY: I have no further questions.

HEARINGS EXAMINER: Very well. Unless there's some objections from someone, we'll recess until 8:30 in the morning.

MR. PETERSON: Does that conclude all the cross-examination?

HEARINGS EXAMINER: That concludes all the cross-

examination. I don't think it's reasonable to leave a witness on from 8:30 past 5:00 o'clock, or my court reporter, either, but if you want to --

MR. PETERSON: I will defer, then, till tomorrow morning. We'll get organized and maybe speed it up.

HEARINGS EXAMINER: Very well, let's recess until in the morning.

(RECESS AT 5:10 P.M.)

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